ROCKEFELLER PHYSICAL LABORATORY OF THE CASE SCHOOL OF APPLIED SCIENCE

Society

FOR THE

Promotion of Engineering Education

PROCEEDINGS

OF THE

FIFTEENTH ANNUAL MEETING

HELD IN

CLEVELAND, OHIO, JULY 1, 2, 3, 1907

Volume XV

EDITED BY

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WILLIAM T. MAGRUDER

BROOKLYN, N. Y.

OFFICE OF THE SECRETARY

PRATT INSTITUTE

1907

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List of Members.

Name and Address.	Title.	Date of Membership.
Abbott, Frederick B. 482 7th St., Brooklyn, N. Y.	Columbia University	1904
Adams, Charles L. Boston, Mass.	Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology	1904
Adams, Comfort A., Jr. Cambridge, Mass.	Professor of Electrical Engineering, Harvard University	1894
Alderson, Victor C. Golden, Colo.	President, Colorado School of Mines	1900
Aldrich, William S. Potsdam, N. Y.	Director, Clarkson School of Technology	1893
Allen, C. Frank Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technology	1893
Allen, Charles M. 10 Dean St., Worcester, Mass.	Professor of Experimental Engineering, Worcester Polytechnic Institute.	1903
Allen, John R. 226 South Ingalls St., Ann Arbor, Mich.	Professor of Mechanical Engineering, University of Michigan	1907
Anderson, Douglas S. New Orleans, La.	Associate Professor of Electrical Engineering, Tulane University	1900
Anderson, F. Paul Lexington, Ky.	Dean of the School of Mechanical and Electrical Engineering, Professor of Mechanical Engineering, State College of Kentucky	1894
Anthony, Gardner C. Tufts College, Mass.	Professor of Technical Drawing and Dean of the Department of Engineering, Tufts College	1896
Anthony, William A. 1427 Madison Ave., New York, N. Y.	Professor of Physics and Electricity and Director of Physical Laboratory, Cooper Union for the Advancement of Science and Art	1907
Arnold, Bion J. Chicago, Ill.	Consulting Electrical Engineer, 1539 Marquette Building	1896

Name and Address.	Title.	Date of Membership.
Atkinson, Fred W. 55 Pineapple St., Brooklyn, N. Y.	President of the Polytechnic Institute of Brooklyn	1905
Austin, Leonard S. Houghton, Mich.	Professor of Metallurgy, Michigan College of Mines	1905
Ayars, William S. Box 302, State College, Pa.	Assistant Professor of Machine Design, Pennsylvania State College	1907
Ayer, Arthur W. 3403 Gray's Ferry Road, Philadelphia, Pa.	General Superintendent, Harrison Bros. & Co., Inc.	1894
Ayres, Brown Knoxville, Tenn.	President of the University of Tennessee	1898
Babcock, Earle J. State University, Grand Forks, N. D.	Dean of the College of Mining Engineering and Professor of Chemistry and Metallurgy, State University and School of Mines of North Dakota	1907
Baker, Ira O. Champaign, Ill.	Professor of Civil Engineering, University of Illinois	1893
Baker, John S. Helena, Mont.	State Engineer's Office of Montana	1904
Ballard, Frederick W. 49 Cadwell Ave., Mayfield Heights, Cleveland, Ohio.	Manager of Engineering and Construction Department, The Sherwin-Williams Co.	1907
Barnes, Fred A. Ithaca, N. Y.	Assistant Professor of Civil Engineering, Cornell University	1904
Barney, Samuel E., Jr. New Haven, Conn.	Assistant Professor of Civil Engineering, Yale University	1894
Barr, John H. Syracuse, N. Y.	Smith Premier Typewriter Company	1902
Barraclough, S. Henry Sydney, N. S. W., Australia.	Lecturer on Mechanism and Applied Thermodynamics, Russell School of Engineering, University of Sydney	1900
Barrows, Harold K. 6 Beacon St., Boston, Mass.	Hydraulic and Sanitary Engineer	1902
Barton Samuel M. Sewanee, Tenn.	Professor of Mathematics, University of the South	1904

Name and Address.	Title.	Date of Membership.
Bass, Frederic H. Minneapolis, Minn.	Assistant Professor of Civil Engineering, University of Minnesota	1904
Bates, Onward 320 Belden Ave., Chicago, Ill.	President of Bates and Rogers Construction Company	1903
Beebe, Murray Charles Madison, Wis.	Associate Professor of Electrical Engineering, University of Wisconsin	1906
Bement, A. American Trust Bldg., Chicago, Ill.	Mining and Mechanical Engineer	1907
Benedict, Harry Yandell Austin, Tex.	Professor of Applied Mathematics, University of Texas	1906
Benjamin, Charles H. Lafayette, Ind.	Dean of the Schools of Engineering, Purdue University	1893
Benton, John R. Gainesville, Fla.	Professor of Physics and Electrical Engineering, University of the State of Florida	1905
Benzenberg, George H. 255 Greenbush St., Milwaukee, Wis.	Consulting Civil Engineer	1907
Betts, Philander The Oakland, 2019 Columbia Road, Washington, D. C.	Assistant Professor in Electrical Engineering, George Washington University, Washington College of Engineering	1907
Beyer, Samuel W. Ames, Iowa.	Professor of Geology and Mining Engineering, Iowa State College	1899
Bishop, Frederick 210 Clara St., Peoria, Ill.	Assistant Professor of Physics and Head of the Department of Physics, Bradley Polytechnic Institute	1907
Bissell, George W. East Lansing, Mich.	Dean of Engineering and Professor of Mechanical Engineering, Michigan Agricultural College	1894
Bixby, William H. Room 508 Federal Bldg., Chicago, Ill.	Lieut. Col. Corps of Engineers, U. S. Army, U. S. Engineer's Office	1898
Black, Adolph New York, N. Y.	Adjunct Professor of Civil Engineering, Columbia University	1907
Blanchard, Arthur H. Brown University, Providence, R. I.	Associate Professor of Civil Engineering, Brown University	1902

Name and Address.	Title.	Date of Membership.
Boardman, Harold S. ..... Orono, Me.	Professor of Civil Engineering, University of Maine...............	1903
Bohannan, Rosser D. .... S. W. Cor. Indianola and 16th Aves., Columbus, Ohio.	Professor of Mathematics, Ohio State University.............	1907
Boughton, Will H. ...... Morgantown, W. Va.	Professor of Civil and Mining Engineering, West Virginia University..	1905
Bovey, Henry T. .... Montreal, Quebec.	Dean of the Faculty of Applied Science, Professor of Civil Engineering and Applied Mechanics, McGill University	1893
Boyd, James E. .... 92 West Lane Ave., Columbus, Ohio.	Professor of Mechanics, Ohio State University.............	1907
Brackett, Byron B. ...... Potsdam, N. Y.	Professor of Physics and Electrical Engineering, Thomas S. Clarkson Memorial School of Technology.....	1906
Bradford, Joseph N. ..... Columbus, Ohio.	Professor of Architecture, Ohio State University	1896
Bray, Charles D. .... Tufts College, Mass.	Professor of Mechanical Engineering, Tufts College	1894
Breckenridge, Lester P. .. Urbana, Ill.	Professor of Mechanical Engineering and Director of Engineering Experiment Station, University of Illinois.	1893
Breed, Charles B. .... Boston, Mass.	Assistant Professor of Civil Engineering, Massachusetts Institute of Technology	1904
Brill, George M. .... 1134 Marquette Bldg., Chicago, Ill.	Consulting Engineer	1894
Brooke, William E. ...... Minneapolis, Minn.	Professor of Mathematics, College of Engineering, University of Minnesota	1902
Brooks, J. Ansel......... Providence, R. I.	Assistant Professor of Mechanical Drawing, Brown University........	1904
Brooks, John P. .... Urbana, Ill.	Associate Professor of Civil Engineering, University of Illinois..........	1898
Brooks, Morgan .... Urbana, Ill.	Professor of Electrical Engineering, University of Illinois..............	1899

Name and Address.	Title.	Date of Membership.
Brown, Harold W. 1141 South Ave., Wilkinsburg, Pa.	Engineer, Westinghouse Electric and Manufacturing Co.	1902
Brown, J. Stanford 10 Belmont Ave., Yonkers, N. Y.	Vice-President and Treasurer, New York Realty Owners Co.	1903
Brown, N. H. College Station, Tex.	Professor of Physics and Electrical Engineering, Agricultural and Mechanical College of Texas	1904
Browne, Wm. Hand, Jr. Wyckoff, N. J.	Technical Editor of the *Electrical Review*, New York	1899
Bruegel, A. Theodore Beloit, Wis.	Mechanical Engineer with Fairbanks, Morse Mfg. Co.	1900
Brydone-Jack, Ernest E. Winnipeg, Manitoba.	Professor of Civil Engineering, University of Manitoba	1902
Bull, Storm Madison, Wis.	Professor of Steam Engineering, University of Wisconsin (Died Nov. 18, 1907.)	1893
Bump, Milan R. 60 Wall St., New York, N. Y.	Director of Experimental Engineering, Henry L. Doherty & Co.	1907
Burger, Charles R. Golden, Colo.	Professor of Mathematics, Colorado School of Mines	1904
Burgess, Charles F. Madison, Wis.	Assistant Professor of Electrical Engineering, University of Wisconsin	1896
Burnham, Raymond 3606 Prairie Ave., Chicago, Ill.	Associate Professor of Experimental Engineering, Armour Institute of Technology	1904
Burr, William H. New York, N. Y.	Professor of Civil Engineering, Columbia University	1893
Burton, Alfred E. Boston, Mass.	Professor of Topographical Engineering, in charge of Department of Drawing and Dean, Massachusetts Institute of Technology	1904
Cajori, Florian 1119 Wood Ave., Colorado Springs, Colo.	Professor of Mathematics and Dean of School of Engineering, Colorado College	1904
Caldwell, Edward 114 Liberty St., New York, N. Y.	Manager, Book Department, McGraw Publishing Co., New York City	1905

Name and Address.	Title.	Date of Membership.
Caldwell, Francis C. .... Columbus, Ohio.	Professor of Electrical Engineering, Ohio State University.............	1897
Camp, Walter M. .... 7740 Union Ave., Chicago, Ill.	Editor of *Railway and Engineering Review*	1904
Carhart, Daniel.......... Wilkinsburg, Allegheny, Pa.	Professor of Civil Engineering and Dean of the Faculty, Western University of Pennsylvania.............	1902
Carpenter, Louis G....... Fort Collins, Colo.	Professor of Civil and Irrigation Engineering, Director of Experiment Station, Colorado State Agricultural College	1895
Carpenter, Rolla C. ...... Ithaca, N. Y.	Professor of Experimental Engineering, Cornell University............	1893
Carson, William W. ..... Knoxville, Tenn.	Professor of Civil Engineering, University of Tennessee............	1894
Chandler, Clarence A. ... East Bridgewater, Mass.	Mechanical Engineer	1902
Chandler, Elwyn F...... University of N. D., Grand Forks, N. D.	Professor of Mathematics, University of North Dakota.......	1907
Chanute, Octave......... 61 Cedar St., Chicago, Ill.	Consulting Engineer	1907
Chase, Charles H. .... 37 Lincoln St., Stoneham, Mass.	Assistant Professor of Steam Engineering, Tufts College.............	1900
Chatburn, George R. ..... Lincoln, Neb.	Professor of Applied Mechanics and Machine Design, University of Nebraska	1899
Christensen, George L. ... Houghton, Mich.	Assistant Professor of Mechanical Engineering, Michigan College of Mines.	1905
Christy, Samuel B. ...... Berkeley, Cal.	Professor of Mining and Metallurgy, University of California...........	1893
Clark, John J. .... 919 Sunset St., Scranton, Pa.	Dean of the Faculty, International Correspondence Schools	1906
Clifford, Harry E. ...... 20 Crystal St., Newton Center, Mass.	Professor of Theoretical Electricity, Massachusetts Institute of Technology	1907

Name and Address.	Title.	Date of Membership.
Clifton, Harry T., 871 North Lake Ave., Pasadena, Cal.	Assistant Professor of Physics, Throop Polytechnic Institute	1907
Colby, Irving A., 89 High St., Exeter, N. H.		1902
Connelley, Clifford B., Ogood and Marepoe Ave. Allegheny, Pa.	Assistant to the Director, Head of the School for Apprentices and Journeymen, Carnegie Technical Schools, Pittsburgh, Pa.	1907
Constant, Frank H., Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota	1896
Cooley, Mortimer E., Ann Arbor, Mich.	Professor of Mechanical Engineering and Dean of Department of Engineering, University of Michigan	1893
Copeland, Durward, Houghton, Mich.	Instructor in Metallurgy, Michigan College of Mines	1905
Corthell, Elmer L., 1 Nassau St., New York, N. Y.	Civil Engineer	1895
Coulter, Stanley, 302 Perrin Ave., Lafayette, Ind.	Professor of Biology and Director of Biological Laboratory, Purdue University	1904
Cox, Nelson H., Lake City, Fla.	Assistant Professor of Civil and Mechanical Engineering, University of the State of Florida	1903
Crandall, Charles L., Ithaca, N. Y.	Professor of Railroad Engineering and Geodesy, Cornell University	1893
Creighton, William H., New Orleans, La.	Professor of Mechanical Engineering, Tulane University	1893
Crenshaw, Bolling H., Auburn, Ala.	Professor of Mathematics, Alabama Polytechnic Institute	1894
Dates, Henry B., Cleveland, Ohio.	Professor of Electrical Engineering, Case School of Applied Science	1904
Davis, Ellery W., Lincoln, Neb.	Dean of College of Literature, Science and the Arts, and Professor of Mathematics, University of Nebraska	1902
Dean, Arthur D., 167 Tremont St., Boston, Mass.	Special Supervisor of Industrial Education, Massachusetts and Rhode Island Y. M. C. A.	1907

Name and Address.	Title.	Date of Membership.
Defoe, Luther M. Columbia, Mo.	Professor of Mechanics, University of Missouri	1904
Denison, Charles S. Ann Arbor, Mich.	Professor of Stereotomy, Mechanism and Drawing, University of Michigan.	1893
Denton, Frederick W. Houghton, Mich.	Superintendent, Baltic and Trimountain Mines	1894
Denton, James E. Hoboken, N. J.	Professor of Engineering Practice, Stevens Institute of Technology	1893
Derleth, Charles, Jr. Berkeley, Cal.	Professor of Structural Engineering, and Dean of the College of Civil Engineering, University of California	1904
Diemer, Hugo State College, Pa.	Professor of Mechanical Engineering, Pennsylvania State College	1902
Doherty, Henry L. 60 Wall St., New York, N. Y.	Consulting Engineer	1904
Dooley, Channing R. 1108 Center St., Wilkinsburg, Pa.	Engineer, Westinghouse Electric and Mfg. Co., and President of Casino Technical Night School	1907
Drane, Walter H. University, Miss.	Professor of Civil Engineering, University of Mississippi	1893
Drinker, Henry S. South Bethlehem, Pa.	President, Lehigh University	1905
Du Bois, A. Jay New Haven, Conn.	Professor of Civil Engineering, Yale University	1894
Dudley, Charles B. Altoona, Pa.	Chemist, Pennsylvania Railroad Company	1894
Dufour, Frank O. Urbana, Ill.	Assistant Professor of Structural Engineering, University of Illinois	1906
Dukes, Richard G. 2257 Murray Hill Road, Cleveland, Ohio.	Assistant Professor of Applied Mechanics and Hydraulics, Case School of Applied Science	1907
Duncan, Louis 56 Pine St., New York, N. Y.	Consulting Electrical Engineer	1904
Duncan, Murray M. Ishpeming, Mich.	Agent, Cleveland Cliffs Iron Co., and Member Board of Control, Michigan College of Mines	1905

Name and Address.	Title.	Date of Membership.
Durand, William F. Stanford University, California.	Professor of Marine Engineering, Leland Stanford Junior University	1899
Eddy, Henry T. Minneapolis, Minn.	Dean of the Graduate School and Professor of Mathematics and Mechanics, College of Engineering, University of Minnesota	1893
Eddy, Horace T. 109 W. Third St., Cincinnati, Ohio.	Machinery Sales Company	1903
Edmands, Samuel S. Brooklyn, N. Y.	Head of Department of Applied Electricity, Pratt Institute	1903
Emory, Frederick L. Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia University	1894
Endsley, Louis E. 815 North 9th St., Lafayette, Ind.	Instructor in Locomotive Laboratory, Purdue University	1907
Engler, Edmund A. Worcester, Mass.	President, Worcester Polytechnic Institute	1897
Ennis, William D. Brooklyn, N. Y.	Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn	1907
Eno, Frank H. 48 Smith Place, Columbus, Ohio.	Professor of Municipal Engineering, Ohio State University	1907
Esterline, J. Walter 401 State St., West Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University	1903
Esty, William South Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1898
Evans, Frederick H. 927 Moss Ave., Peoria, Ill.	Assistant in Manual Arts, Bradley Polytechnic Institute	1907
Evans, Herbert S. Boulder, Colo.	Professor of Electrical Engineering, University oi Colorado	1905
Faig, John T. 254 Greendale Ave., Clifton, Cincinnati, Ohio.	Professor of Mechanical Engineering, University of Cincinnati	1899

Name and Address.	Title.	Date of Membership.
Fairfield, Howard P. .... 25 John St., Worcester, Mass.	Instructor in Shop Engineering, Worcester Polytechnic Institute....	1907
Farwell, Elmer S. .... 309 Broadway, New York, N. Y.	Consulting Engineer	1895
Fermier, Emilie J. .... College Station, Texas.	Professor of Mechanical Engineering, Texas Agricultural and Mechanical College	1903
Fernald, Robert H. .... Cleveland, Ohio.	Professor of Mechanical Engineering, Case School of Applied Science.....	1899
Fish, Fred A. .... Ames, Iowa.	Professor of Electrical Engineering, Iowa State College................	1905
Fisher, James, Jr. .... Houghton, Mich.	Professor of Mathematics and Physics, Michigan College of Mines......	1899
Flather, John J. .... Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota...........	1893
Fletcher, Robert .... Hanover, N. H.	Professor of Civil Engineering, Director of Thayer School of Civil Engineering, Dartmouth College....	1894
Focke, Theodore M. ...... 2057 Cornell Road, Cleveland, Ohio.	Assistant Professor of Mathematics, Case School of Applied Science.....	1907
Ford, Arthur H. .... Iowa City, Iowa.	Professor of Electrical Engineering, State University of Iowa..........	1903
Foss, Fred E. .... Pittsburg, Pa.	Professor of Civil Engineering Practice, Carnegie Technical Schools....	1893
Fowler, Charles E. ...... 737 New York Block, Seattle, Wash.	President of International Contract Co., and Lecturer, University of Washington	1903
Foyé, Andrew E. .... 21 Park Row, New York, N. Y.	Secretary and Treasurer, Ryan-Parker Construction Company	
Frankforter, George B. .. Minneapolis, Minn.	Professor of Chemistry, University of Minnesota..........	1897
Franklin, William S. .... Bethlehem, Pa.	Professor of Physics, Lehigh University	1900

Name and Address.	Title.	Date of Membership.
Freedman, William H. .... 100 South Union St., Burlington, Vt.	Professor of Electrical Engineering, University of Vermont.............	1902
Freeman, Clarence E. .... Chicago, Ill.	Director of Electrical Engineering Department, Armour Institute of Technology	1904
French, Arthur W. ...... Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute.....	1900
French, Thomas E. ...... Columbus, Ohio.	Professor of Engineering Drawing, Ohio State University.............	1899
Frink, Fred G. .... 115 Chicago Ave., Kankakee, Ill.	Civil Engineer......................	1902
Frost, G. Harwood....... 220 Broadway, New York, N. Y.	Editor and Publisher, *Technical Literature*, Manager, Book and Circulation Departments, *Engineering News*.	1907
Fuller, Almon H. .... University Station, Seattle, Wash.	Professor of Civil Engineering and Dean of the College of Engineering, University of Washington..........	1901
Furman, Franklin DeR... 700 Hudson St., Hoboken, N. J.	Professor of Mechanical Drawing and Designing, Stevens Institute of Technology	1907
Galbraith, John .... Toronto, Ont.	Principal and Professor of Engineering, School of Practical Science.....	1893
Ganz, Albert F. .... Hoboken, N. J.	Professor of Electrical Engineering, Stevens Institute of Technology.....	1903
Garman, Harry O. .... 739 Owen St., Lafayette, Ind.	Assistant Professor of Civil Engineering, Purdue University............	1907
Gavett, George I. .... 5525 16th Ave., N. E., Seattle, Wash.	Instructor in Mathematics, University of Washington..........	1907
Gehring, Herbert A. ..... 60 South Main St., Homer, N. Y.	Instructor in Civil Engineering, Cornell University	1907
Giesecke, F. E. .... Berliner Strasse 46, Charlottenburg, Germany.	Professor of Drawing, Texas Agricultural and Mechanical College.......	1893
Gill, James H. .... Urbana, Ill.	Assistant Professor of Machine Construction, University of Illinois.....	1896

Name and Address.	Title.	Date of Membership.
Gillette, Halbert P. ..... 1120–1121 Park Row Bldg., New York, N. Y.	Consulting Engineer................	1905
Gladson, William N. ..... Fayetteville, Ark.	Professor of Electrical Engineering, University of Arkansas............	1903
Goetze, Frederick A. ..... New York, N. Y.	Dean of the Schools of Mines, Engineering and Chemistry, Columbia University	1906
Goodenough, George A. ... Urbana, Ill.	Associate Professor of Mechanical Engineering, University of Illinois....	1900
Goss, William F. M. ..... Urbana, Ill.	Dean of the College of Engineering, University of Illinois..............	1893
Grant, Elmer D. .... Houghton, Mich.	Assistant Professor of Mathematics and Physics, Michigan College of Mines	1905
Gray, Thomas............ Terre Haute, Ind.	Professor of Dynamic Engineering, Rose Polytechnic Institute.........	1895
Gregory, William B. ..... 630 Pine St., New Orleans, La.	Professor of Experimental Engineering, The Tulane University of Louisiana	1907
Green, Bernard R. .... 1738 N St., Washington, D. C.	Superintendent of Buildings and Grounds, Library of Congress......	1906
Green, James A. .... Scottsbluff, Neb.	Chief Engineer, Tri-State Land Co. ..	1904
Greene, Arthur M., Jr. ... Troy, N. Y.	Professor of Mechanical Engineering, Rensselaer Polytechnic Institute....	1903
Groat, Benjamin F. .... Minneapolis, Minn.	Professor of Mechanics and Mathematics, School of Mines, University of Minnesota	1899
Grover, Nathan C. .... 81 North 18th St., East Orange, N. J.	Assistant Hydraulic Engineer, J. G. White & Co., 43 Exchange Place, New York, N. Y.	1894
Halsey, Frederick A. .... Hill Publishing Co., 505 Pearl St., New York, N. Y.	Editor-in-Chief, *American Machinist*..	1907
Hamerschlag, Arthur A. . Pittsburg, Pa.	Director, Carnegie Technical Schools..	1903

Name and Address.	Title.	Date of Membership.
Hancock, Edward L. ...... Lafayette, Ind.	Assistant Professor of Applied Mechanics, Purdue University.........	1903
Harrington, John Lyle... 608 New Nelson Bldg., Kansas City, Mo.	Consulting Engineer, Waddell & Harrington	1903
Harris, Abram W. .... Evanston and Chicago, Ill.	President, Northwestern University...	1897
Harris, Elmo G. .... Rolla, Mo.	Professor of Civil Engineering, School of Mines and Metallurgy, University of Missouri	1894
Haskell, Eugene E. ..... Ithaca, N. Y.	Director, College of Civil Engineering, Cornell University	1907
Hatt, William K. .... Lafayette, Ind.	Professor of Civil Engineering, Purdue University	1895
Haupt, Lewis M. .... 107 North 35th St., Philadelphia, Pa.	Consulting Engineer	1907
Haviland, Edwin, Jr. ..... 4245 Brooklyn Ave., Seattle, Wash.	University of Washington	1902
Hawes, Joseph H. .... 40 Fairmont St., Dorchester, Mass.	Teacher of Manual Training and Mechanical Drawing, Dorchester High School, Boston.....................	1900
Hayford, John F. .... Washington, D. C.	Inspector of Geodetic Work and Chief of Computing Division, Coast and Geodetic Survey	1905
Haynes, Arthur E. .... Minneapolis, Minn.	Professor of Engineering Mathematics, University of Minnesota...........	1895
Hayward, Harrison W. ... Boston, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technology	1904
Hazelton, William S. ... 802 Monroe St., Ann Arbor, Mich.	Assistant Professor of Mechanical Engineering, University of Michigan..	1907
Hazen, John V. .... Hanover, N. H.	Professor of Civil Engineering, Dartmouth College	1896

Name and Address.	Title.	Date of Membership.
Hedrick, Ira G. Keith and Perry Bldg., Kansas City, Mo.	Consulting Engineer	1894
Henley, William W. R. F. D. No. 1, Tucson, Ariz.	Professor of Mechanic Arts, University of Arizona	1907
Herget, Albert M. 107 Boyd Ave., Baton Rogue, La.	Professor of Drawing and Mechanic Arts, Louisiana State University	1903
Hibbard, Angus S. 203 Washington St., Chicago, Ill.	2d Vice-President and General Manager, Chicago Telephone Company	1907
Hibbard, H. Wade. Ithaca, N. Y.	Professor of Mechanical Engineering of Railways, Sibley College, Cornell University	1896
Higbee, Fred. Goodsen. Iowa City, Ia.	Assistant Professor, and Head of the Department of Drawing and Descriptive Geometry, State University of Iowa	1906
Hill, John E. Providence, R. I.	Professor of Civil Engineering, Brown University	1894
Hitchcock, Embury A. Columbus, Ohio.	Professor of Experimental Engineering, Ohio State University	1899
Hoffman, Arthur H. 710 Clark St., Ames, Iowa.	Assistant Professor of Electrical Engineering, Iowa State College of Agriculture and Mechanic Arts	1907
Hoffman, James D. 310 State St., West Lafayette, Ind.	Associate Professor of Engineering Design, Purdue University	1907
Hofman, Heinrich O. Boston, Mass.	Professor of Metallurgy, Massachusetts Institute of Technology	1894
Holden, Charles A. Hanover, N. H.	Associate Professor of Civil Engineering, Thayer School of Civil Engineering, Dartmouth College	1901
Hollis, Ira N. Cambridge, Mass.	Professor of Engineering, Harvard University	1894
Hood, Ozni P. Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893

Name and Address.	Title.	Date of Membership.
Horton, George F. .... Throop and 105th Sts., Chicago, Ill.	Vice-President of Chicago Bridge and Iron Co.	1903
Hoskins, Leander M. ..... Stanford University, Cal.	Professor of Applied Mathematics, Leland Stanford Junior University..	1893
Howe, Charles S. .... Cleveland, Ohio.	President of Case School of Applied Science	1902
Howe, Malverd A. .... Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute..........	1894
Hughes, John W. .... 775 Hattie St., Schenectady, N. Y.	Assistant Professor of Civil Engineering, Union University.............	1907
Hume, Alfred............. University, Miss.	Professor of Mathematics, University of Mississippi..........	1894
Humphreys, Alexander C. Hoboken, N. J.	President of Stevens Institute of Technology	1903
Humphreys, David C. ..... Lexington, Va.	Dean of the School of Engineering and Professor of Civil Engineering, Washington and Lee University....	1893
Hunter, John A. .... Boulder, Colo.	Professor of Mechanical Engineering, University of Colorado.............	1904
Huntington, Edward V.... 35 Fairfax Hall, Cambridge, Mass.	Assistant Professor of Mathematics, Harvard University................	1906
Hutton, Frederick R. .... New York, N. Y.	Emeritus Professor of Mechanical Engineering, Columbia University.....	1894
Hyde, A. Lincoln.......... University Club, Columbia, Mo.	Assistant Professor of Bridge Engineering, University of Missouri.....	1904
Ives, Howard C. .... Worcester, Mass.	Assistant Professor of Railroad Engineering, Worcester Polytechnic Institute	1901
Jackson, Dugald C. ...... Boston, Mass.	Professor of Electrical Engineering, Massachusetts Institute of Technology	1893
Jackson, John P. .... State College, Pa.	Professor of Electrical Engineering, Pennsylvania State College.........	1894
Jacobus, D. S. .... New York, N. Y.	Babcock & Wilcox Company..........	1893

Name and Address.	Title.	Date of Membership.
Jacoby, Henry S., Ithaca, N. Y.	Professor of Bridge Engineering, Cornell University	1894
James, Walter H., Boston, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technology	1904
Jameson, Joseph M., Brooklyn, N. Y.	Head of Department of Physics, Pratt Institute	1903
Jenkins, A. Lewis, 2104 Fulton Ave., Walnut Hills, Cincinnati, Ohio.	Assistant Professor of Mechanical Engineering, University of Cincinnati	1907
Jenkins, David Rhys, 815 Spruce St., Boulder, Colo.	Instructor in Electrical Engineering, University of Colorado	1906
Jenson, Joseph, Logan, Utah.	Professor of Mechanical Engineering, State Agricultural College of Utah	1903
Johnson, John W., Lock Box 40, University, Miss.	Professor of Physics, University of Mississippi	1907
Johnson, Lewis J., Cambridge, Mass.	Professor of Civil Engineering, Harvard University	1898
Jones, Bassett, Jr., 1 Madison Ave., New York, N. Y.	Consulting Engineer	1904
Jones, Clement R., Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University	1895
Jones, Forrest R., 315 W. 96 St., New York, N. Y.	Professor of Manhattan Automobile School	1893
Jones, Frederick S., Minneapolis, Minn.	Professor of Physics and Dean of College of Engineering, University of Minnesota	1903
Judd, Horace, 245 W. 4th Ave., Columbus, Ohio.	Assistant Professor of Experimental Engineering, Ohio State University.	1907
Kaup, William J., Brooklyn, N. Y.	Instructor in Machine Construction, Pratt Institute	1903
Kavanaugh, William H., Minneapolis, Minn.	Professor of Experimental Engineering, University of Minnesota	1902
Kay, Edgar B., University, Ala.	Professor of Civil Engineering, University of Alabama	1898

Name and Address.	Title.	Date of Membership.
Kelly, William, Vulcan, Mich.	Agent Penn Iron Mining Company and Chairman Board of Control Michigan College of Mines	1905
Kenerson, William H., 100 Morris Ave., Providence, R. I.	Associate Professor of Mechanical Engineering, Brown University	1903
Kennedy, Frank Lowell, 43 Appleton St., Cambridge, Mass.	Assistant Professor of Drawing and Machine Design, Harvard University.	1904
Kent, James M., Kansas City, Mo.	Instructor in Steam and Electricity, Manual Training High School of Kansas City	1903
Kent, William, Syracuse, N. Y.	Dean of the College of Applied Science and Professor of Mechanical Engineering, Syracuse University	1894
Kerr, Charles V., Wellsville, N. Y.	Chief Engineer, Kerr Turbine Co.	1902
Ketchum, Milo S., Boulder, Colo.	Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado	1903
King, Roy S., 1911 N. Main St., Dayton, Ohio.	Assistant Manager, Keppele Hall Co.	1904
Kingsbury, Albert, East Pittsburg, Pa.	Mechanical Engineer with Westinghouse Electrical and Manufacturing Company	1893
Kinsley, Carl, 5454 Greenwood Ave., Chicago, Ill.	Assistant Professor of Physics, University of Chicago	1903
Kirchhoff, Charles, 422 West End Ave., New York, N. Y.	General Manager and Vice-President, David Williams Company, Publishers	1907
Knight, Carl D., 31 Hackfeld Road, Worcester, Mass.	Instructor in Experimental Electrical Engineering, Worcester Polytechnic Institute	1907
Knight, William A., 206 W. Lane Ave., Columbus, Ohio.	Assistant Professor of Machine-Shop Practice, Ohio State University	1907
Knipp, Charles T., 502 W. Illinois St., Urbana, Ill.	Assistant Professor of Physics, University of Illinois	1907

Name and Address.	Title.	Date of Membership.
Knoch, Julius J., Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas	1898
Koch, Ernest H., Jr., 421 Park Place, Brooklyn, N. Y.	Instructor in Pratt Institute	1904
Kortright, Frederic L., 234 Jackson Ave., Morgantown, W. Va.	Professor of Chemistry, West Virginia University	1907
Kunze, Edward J., 800 Broad St., Newark, N. J.	Consulting Engineer	1897
Kyser, Henry H., Talladega, Ala.	Electrical Engineer	1907
Ladd, George E., Rolla, Mo.	Director and Professor of Geology and Mining, School of Mines and Metallurgy	1901
Lambert, Byron J., 215 Fairchild St., Iowa City, Ia.	Professor of Structural Engineering, State University of Iowa	1907
Lambert, Preston A., South Bethlehem, Pa.	Assistant Professor of Mathematics, Lehigh University	1897
Landreth, Olin H., Schenectady, N. Y.	Professor of Civil Engineering, Union University	1893
Lane, Henry M., 610 Schofield Building, Cleveland, Ohio.	Secretary, The Foundry Supply Association, Editor *Castings*	1900
Langsdorf, Alexander S., St. Louis, Mo.	Professor of Electrical Engineering, Washington University	1903
Lanza, Gaetano, Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology	1893
Lawrance, Charles H., 1022 First St., W. Lafayette, Ind.	Instructor in Mechanics, Purdue University	1906
Lawrence, James W., Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College	1898
Leeds, Charles C., 5508 Elmer St., Pittsburg, Pa.	Assistant Head of School of Apprentices and Journeymen, and Instructor of Mechanical Drawing, Carnegie Technical Schools	1907

Name and Address.	Title.	Date of Membership.
Leutwiler, Oscar Adolph. 511 West Green St., Urbana, Ill.	Assistant Professor of Machine Design, University of Illinois	1906
Lindemann, Charles A. Lewisburg, Pa.	Assistant Professor of Applied Mathematics, Bucknell University	1905
Linville, Clarence P. State College, Pa.	Assistant Professor of Metallurgy, School of Mines and Metallurgy, Pennsylvania State College	1904
Longyear, John M. Marquette, Mich.	Member Board of Control, Michigan College of Mines	1904
Lord, Nathaniel W. 338 W. 8th Ave., Columbus, Ohio.	Professor of Metallurgy and Mineralogy and Director of the School of Mines, Ohio State University	1907
Love, A. Cavitt. Breaux Bridge, La.	Engineer, Morgan's Louisiana and Texas Steamship and Railroad Co.	1900
Lucke, Charles Edward. New York, N. Y.	Adjunct Professor of Mechanical Engineering, Columbia University	1906
Ludy, Llewellyn V. 229 University St., West Lafayette, Ind.	Professor of Mechanical Engineering, Purdue University	1903
McCaustland, Elmer J. University, Ala.	Professor of Mining, University of Alabama	1902
McKibben, Frank P. South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University	1904
McNair, Fred W. Houghton, Mich.	President, Michigan College of Mines.	1897
McNown, William C. 418 Randolph St., Richmond, Ind.	Professor of Civil Engineering, Earlham College	1907
MacDaniel, Allen B. Vermillion, S. D.	Assistant Professor of Civil Engineering, University of South Dakota	1907
MacNaughton, James. Calumet, Mich.	General Manager, Calumet and Hecla Mines, and Member Board of Control, Michigan College of Mines	1905
Mabery, Charles F. 1949 E. 107th St., Cleveland, Ohio.	Professor of Chemistry, Case School of Applied Science	1907
Mack, John G. D. 110 E. Johnson St., Madison, Wis.	Professor of Machine Design, College of Engineering, University of Wisconsin	1901

Name and Address.	Title.	Date of Membership.
Macomber, George S. Ithaca, N. Y.	Assistant Professor of Electrical Engineering, Sibley College, Cornell University	1904
Magnusson, C. Edward. University Station, Seattle, Wash.	Professor of Electrical Engineering, University of Washington	1907
Magowan, Charles S. Iowa City, Iowa.	Professor of Municipal and Sanitary Engineering, State University of Iowa (Died, Nov. 14, 1907)	1896
Magruder, William T. Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University	1893
Maitland, Alexander, Jr. Kansas City, Mo.	President of Kansas City Bridge Co.	1903
Marburg, Edgar Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania	1894
Marston, Anson Ames, Iowa.	Dean of the Division of Engineering and Professor of Civil Engineering, Iowa State College	1894
Martin, Louis A., Jr. 824 Bloomfield St., Hoboken, N. J.	Assistant Professor of Mathematics and Mechanics, Stevens Institute of Technology	1907
Marvin, Frank O. Lawrence, Kan.	Dean of the School of Engineering and Professor of Civil Engineering, University of Kansas	1893
Marx, Charles D. Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University	1893
Mathews, Hubert B. Brookings, S. Dak.	Professor of Physics and Electrical Engineering, South Dakota Agricultural College	1896
Matthews, Charles P. Lafayette, Ind.	Professor of Electrical Engineering, Purdue University (died November 23, 1907)	1898
Maurer, Edward R. Madison, Wis.	Professor of Mechanics, University of Wisconsin	1897
Mead, Elwood Washington, D. C.	Chief of Irrigation and Drainage Investigations of the U. S. Department of Agriculture	1901
Meeker, Warren H. Ames, Iowa.	Professor of Mechanical Engineering, Iowa State College	1903
Mees, Carl L. Terre Haute, Ind.	President, Rose Polytechnic Institute	1894

Name and Address.	Title.	Date of Membership.
Mendenhall, Thomas C. .. Care of Brown, Shipley & Co., 123 Pall Mall, London, England.		1895
Merrill, Joseph F. .... Salt Lake City, Utah.	Director, Utah State School of Mines, Professor of Physics and Electrical Engineering, University of Utah...	1907
Merriman, Mansfield .... 45 Broadway, New York, N. Y.	Consulting Engineer	1893
Miggett, William L. ...... 331 Jefferson St., Ann Arbor, Mich.	Superintendent of the Engineering Shops, University of Michigan......	1902
Millar, Adam V. .... 222 Charter St., Madison, Wis.	Instructor in Mechanical Drawing and Descriptive Geometry, University of Wisconsin	1904
Miller, Dayton C. .... Cleveland, Ohio.	Professor of Physics, Case School of Applied Science.....	1907
Mitcham, George Nathan. Auburn, Ala.	Professor of Civil Engineering, Alabama Polytechnic Institute......	1906
Molitor, David A. .... 822 Mills Bldg. Annex, Washington, D. C.	U. S. Assistant Engineer, Isthmian Canal Commission.......	1907
Monin, Louis C. .... Chicago, Ill.	Dean of Culture Studies and Professor of Economics and Philosophy, Armour Institute of Technology....	1904
Moore, Herbert F. .... Champaign, Ill.	Assistant Professor of Theoretical and Applied Mechanics, University of Illinois........................	1905
Moore, Lewis E. .... 85 Washington Park, Newtonville, Mass.	Assistant Professor of Civil Engineering, Massachusetts Institute of Technology	1907
Moore, Stanley H. .... St. Louis, Mo.	Director, Manual Training Department, McKinley High School........	1902
Moran, Daniel E. .... 35 Nassau St., New York, N. Y.	Secretary and Engineer of Foundation and Contracting Co., New York City	1903
More, Charles C. .... University Station, Seattle, Wash.	Associate Professor of Civil Engineering, University of Washington......	1901
Morley, Frederick .... Lapeer, Mich.	Res. Engr., St. Clair Flats Survey for the State of Michigan.............	1896

Name and Address.	Title.	Date of Membership.
Morris, Clyde T. 369 E. 15th Ave., Columbus, O.	Associate Professor of Civil Engineering, Ohio State University	1907
Morrison, Charles E. New York, N. Y.	Tutor, Department of Civil Engineering, Columbia University	1907
Morse, George H. 350 North 28th St., Lincoln, Neb.	Professor of Electrical Engineering, University of Nebraska	1907
Moseley, Alexander W. 798 Monroe St., Chicago, Ill.	Professor of Theoretical and Applied Mechanics, Head of Department of Mechanical Engineering, Lewis Institute	1907
Mott, William E. 174 Harvard St., Brookline, Mass.	Associate Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1907
Moyer, James A. 417 W. 118th St., New York, N. Y.		1904
Munroe, Henry S. New York, N. Y.	Professor of Mining, Columbia University	1893
Munroe, James P. 79 Summer St., Boston, Mass.	Treasurer, Munroe Felt and Paper Co., Secretary of Corporation of Massachusetts Institute of Technology	1904
Myers, Ralph E. State College, Pa.	Assistant Professor of Electrochemical Engineering, Pennsylvania State College	1907
Nagle, James C. College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas	1897
Neff, Frank H. Cleveland, Ohio.	Professor of Civil Engineering, Case School of Applied Science	1895
Nesbit, Arthur F. Durham, N. H.	Professor of Physics and Electrical Engineering, New Hampshire College of Agriculture and Mechanic Arts	1902
Norris, Henry H. Ithaca, N. Y.	Professor of Electrical Engineering, Cornell University	1900
Nunn, Paul N. Provo, Utah.	Chief Engineer, The Telluride Power Co., and Consulting Engineer	1907
O'Byrne, J. F. Dahlonega, Ga.	Professor of Mining and Electrical Engineering, N. G. A. College	1905

Name and Address.	Title.	Date of Membership.
Ohle, Ernest L. Iowa City, Ia.	Professor of Steam Engineering and Head of the Department of Mechanical Engineering, State University of Iowa	1905
Olsen, Tinius 500 N. 12th St., Philadelphia, Pa.	Mechanical Engineer	1907
Orton, Edward, Jr. Columbus, Ohio.	Director of the Department of Clay Working and Ceramics, Ohio State University	1900
Osborn, Frederick A. 5215 15th Ave., N. E., Seattle, Wash.	Professor of Physics, University of Washington	1907
Ostrander, John E. Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College	1894
Owens, Robert B. Montreal, Quebec.	Professor of Electrical Engineering, McGill University	1894
Palmer, Thomas W. Montevallo, Ala.	President of the Alabama Girls' Industrial School	1905
Palmer, Walter K. 718 Dwight Bldg., Kansas City, Mo.	Consulting Mechanical and Electrical Engineer	1899
Park, Charles F. 62 Summer St., Taunton, Mass.	Associate Professor of Mechanical Engineering, Massachusetts Institute of Technology	1903
Parker, Lawrence G. 705 S. 6th St., Champaign, Ill.	Instructor in Civil Engineering, University of Illinois	1907
Parsons, Floyd W. 505 Pearl St., New York, N. Y.	Associate Editor, *Engineering and Mining Journal*	1905
Patterson, Andrew H. Athens, Ga.	Professor of Physics and Astronomy, University of Georgia	1907
Pence, William D. Madison, Wis.	Professor of Railway Engineering, University of Wisconsin	1895
Pettee, Charles H. Durham, N. H.	Professor of Mathematics, New Hampshire College	1898
Phelon, Joseph O. 27 Schussler Road, Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute	1907

Name and Address.	Title.	Date of Membership.
Phetteplace, Thurston M. 1612 Broad St., Providence, R. I.	Instructor in Mechanical Engineering, Brown University	1903
Phillips, James D. Madison, Wis.	Professor of Drawing, University of Wisconsin	1899
Pierce, Charles Henry. 35 No. Converse Hall, Burlington, Vt.	Assistant Professor of Mathematics (Engin.), University of Vermont	1906
Plumb, Hylon T. 318 Waldron St., Lafayette, Ind.	Associate Professor of Electrical Engineering, Purdue University	1907
Porter, Dwight. Boston, Mass.	Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1893
Porter, J. Madison. Easton, Pa.	Professor of Civil Engineering, Lafayette College	1893
Porter, John B. Montreal, Quebec.	Professor of Mining Engineering, McGill University	1904
Powell, Emery H. 1538 Madison Ave., Scranton, Pa.	Engineering Textbook Writer, International Correspondence Schools	1903
Price, Melvin. Lafayette, Ind.		1900
Pritchett, Henry S. 542 Fifth Ave., New York, N. Y.	President, Carnegie Foundation for the Advancement of Teaching	1904
Pupin, Michael I. New York, N. Y.	Professor of Electromechanics, Columbia University	1895
Puryear, Charles. College Station, Tex.	Professor of Mathematics, Agricultural and Mechanical College of Texas	1901
Radtke, Albert A. 244 47th St., Chicago, Ill.	Professor of Electrical Engineering, Armour Institute of Technology	1907
Randall, Otis E. Providence, R. I.	Professor of Mechanics and Mechanical Drawing, Brown University	1903
Randolph, Lingan S. Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute	1894

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
RANSOM, JAMES H. 323 University St., West Lafayette, Ind.	Professor of General Chemistry, Purdue University	1904
RAUTENSTRAUCH, WALTER New York, N. Y.	Adjunct Professor of Mechanical Engineering, Columbia University	1907
RAY, FRANKLIN A. 137 King Ave., Columbus, Ohio.	Professor of Mine Engineering, Dean of the College of Engineering, Ohio State University	1906
RAYMOND, HOWARD M. Chicago, Ill.	Dean of Engineering Studies and Professor of Experimental Physics, Armour Institute of Technology	1904
RAYMOND, WILLIAM G. Iowa City, Iowa.	Dean of College of Applied Science and Professor of Civil Engineering, State University of Iowa	1893
REBER, LOUIS E. Madison, Wis.	Director, University Extension, University of Wisconsin	1893
REID, CLARENCE E. 1848 101st St., N. E., Cleveland, Ohio.	Assistant Professor of Electrical Engineering, Case School of Applied Science	1907
REYNOLDS, HERMAN W. Berkeley, Cal.	Assistant Professor of Mechanical Engineering, University of California	1903
RICHARDS, CHARLES RUSS Lincoln, Neb.	Professor of Mechanical Engineering and Director of the School of Mechanic Arts, University of Nebraska.	1895
RICHARDS, CHAS. RUSSELL. New York, N. Y.	Director of Manual Training, Teachers College, Columbia University	1904
RICHARDS, ROBERT H. Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology	1895
RICHEY, ALBERT S. 12 Schussler Road, Worcester, Mass.	Professor of Electric Railway Engineering, Worcester Polytechnic Institute	1907
RICHTER, ARTHUR W. Madison, Wis.	Professor of Experimental Engineering, University of Wisconsin	1894
RICKER, N. CLIFFORD Urbana, Ill.	Professor of Architecture, University of Illinois	1894
RIGGS, WALTER M. Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Department of Mechanical and Electrical Engineering, Clemson A. and M. College of South Carolina	1897

Name and Address.	Title.	Date of Membership.
Rittenhouse, Leon H. .... Haverford, Pa.	Instructor in Engineering, Haverford College..................	1906
Robbins, Arthur G. ...... Boston, Mass.	Associate Professor of Topographical Engineering, Massachusetts Institute of Technology	1894
Roberts, William J. ...... Pullman, Wash.	Associate Professor of Mathematics and Civil Engineering, Washington Agricultural College and School of Science	1903
Robinson, Edward......... Burlington, Vt.	Professor of Mechanical Engineering, University of Vermont.............	1899
Robinson, Frederic H. .... Newark, Del.	Professor of Civil Engineering, Delaware College	1894
Robinson, Stillman W. ... 1353 Highland St., Columbus, Ohio.	Mechanical Engineer and Expert, Emeritus Professor of Mechanical Engineering, Ohio State University..	1893
Rodhouse, Thomas J. ..... Columbia, Mo.	Assistant Professor of Hydraulic Engineering, University of Missouri.	1904
Rondinella, Lino F. ...... 728 Stephen Girard Bldg., Philadelphia, Pa.	Head of Drawing Department, Central Manual Training High School of Philadelphia	1903
Rosebrugh, Thomas R. .... Toronto, Ontario.	Associate Professor of Electrical Engineering, School of Practical Science.	1896
Rouillion, Louis, 20 West 44th St., New York, N. Y.	Director, Mechanics' Institute........	1906
Rowe, George H. .... 1211 Fisher Building, Chicago, Ill.	Consulting Engineer	1906
Rowland, Arthur J. ...... 4510 Osage Ave., Philadelphia, Pa.	Professor of Electrical Engineering, Drexel Institute..................	1903
Rugan, Henry F. .... 4909 Carondelet St., New Orleans, La.	Associate Professor of Mechanic Arts and Erecting Engineering, Tulane University of Louisiana...........	1907
Russell, Walter B. ...... 749 Eastern Parkway, Brooklyn, N. Y.	Assistant Superintendent of Apprentices, N. Y. C. Lines..............	1903

Name and Address.	Title.	Date of Membership
Ryan, Harris J. Stanford University, Cal.	Professor of Electrical Engineering, Leland Stanford Junior University	1901
Sadler, Herbert C. 705 South State St., Ann Arbor, Mich.	Professor of Naval Architecture and Marine Engineering, University of Michigan	1907
Sanborn, Frank E. Columbus, Ohio.	Director, Industrial Arts Department, Ohio State University	1899
Sawyer, Arthur R. East Lansing, Mich.	Professor of Physics and Electrical Engineering, Michigan Agricultural College	1907
Schmidt, Edward C. 903 W. California Ave., Urbana, Ill.	Associate Professor of Railway Engineering, University of Illinois	1907
Schneider, Herman Cincinnati, Ohio.	Professor of Civil Engineering and Dean of the College of Engineering, University of Cincinnati	1903
Schuerman, William H. Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University	1895
Scott, Arthur C. Austin, Tex.	Professor of Electrical Engineering, University of Texas	1903
Scott, Charles F. Pittsburg, Pa.	Consulting Engineer, Westinghouse Electric and Manufacturing Company	1904
Scrugham, James G. Monroe House, Reno, Nevada.	Professor of Mechanical Engineering, Nevada State University	1906
Sears, Thomas B. Sta. A, Lincoln, Neb.	Instructor in Civil Engineering, University of Nebraska	1906
Sedgwick, William T. Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology	1896
Sever, George F. New York, N. Y.	Professor of Electrical Engineering, Columbia University	1903
Shattuck, Harold Bemis State College, Pa.	Assistant Professor of Civil Engineering, Pennsylvania State College	1906
Shaw, Howard B. 511 Rollins Road, Columbia, Mo.	Professor of Electrical Engineering, University of Missouri	1907

Name and Address.	Title.	Date of Membership.
Sheldon, Samuel......... Brooklyn, N. Y.	Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn......................	1903
Shepardson, George D. ... Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota...........	1895
Sherman, Christopher E. 230 W. 10th Ave., Columbus, Ohio.	Professor of Civil Engineering, Ohio State University.............	1907
Shoop, Charles Franklin. Minneapolis, Minn.	Instructor in Mechanical Engineering and Assistant in Mathematics, University of Minnesota..........	1906
Short, Robert L. .... Chicago, Ill.	Mathematical Editor, D. C. Heath & Co.	1902
Shoudy, William A. ..... 520 Hudson St., Hoboken, N. J.	Instructor in Experimental Engineering, Stevens Institute of Technology.	1907
Shuster, John W. .... 235 W. Gilman St., Madison, Wis.	Assistant Professor of Electrical Engineering, University of Wisconsin..	1907
Slichter, Charles S. ..... Madison, Wis.	Professor of Applied Mathematics, University of Wisconsin...........	1906
Slocum, Roy H. .... Agricultural College, N. D.	Professor of Civil Engineering, North Dakota Agricultural College........	1903
Slocum, Stephen E. ...... Cincinnati, Ohio.	Professor of Applied Mathematics, University of Cincinnati..........	1906
Smart, George........... 10608 Massie Ave., Cleveland, Ohio.	Editor, *Iron Trade Review*..........	1907
Smith, Albert W. .... 1101 East Madison Ave., Cleveland, Ohio.	Professor of Metallurgy, Case School of Applied Science................	1904
Smith, Alton L. .... Worcester, Mass.	Assistant Professor of Drawing and Machine Design, Worcester Polytechnic Institute......................	1902
Smith, Earl B. .... Philadelphia, Pa.	Instructor in Charge of Mechanical Engineering Laboratories, Drexel Institute	1906
Smith, Harold B. .... Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute....	1898

Name and Address.	Title.	Date of Membership.
Smith, Harry E. 1346 West Wood St., Decatur, Ill.	Professor of Mechanical Engineering, James Millikin University	1895
Smith, Herbert S. S. Princeton, N. J.	Professor of Applied Mechanics, Princeton University	1894
Smith, Leonard S. 938 University Ave., Madison, Wis.	Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin	1903
Smyth, Henry L. 9 Buckingham St., Cambridge, Mass.	Professor of Mining, Harvard University	1907
Snow, Charles H. New York, N. Y.	Dean of School of Applied Science and Professor of Civil Engineering, New York University	1895
Snow, Walter B. 29 Russell Ave., Watertown, Mass.	Publicity Engineer, 170 Summer St., Boston, Mass.	1899
Solberg, Halvor C. Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College	1894
Spalding, Frederick P. Columbia, Mo.	Professor of Civil Engineering, University of State of Missouri	1893
Spangler, Henry W. Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania	1895
Speer, Frederick W. Houghton, Mich.	Professor of Civil and Mining Engineering, Michigan College of Mines	1896
Spinney, Louis B. Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State College	1899
Spofford, Charles M. Brooklyn, N. Y.	Professor of Civil Engineering, Polytechnic Institute	1904
Springer, Frank W. Minneapolis, Minn.	Assistant Professor of Electrical Engineering, University of Minnesota	1896
Stanford, J. Verne. Engineering Building, University of Penn., Philadelphia, Pa.	Assistant Professor of Mechanical Engineering, University of Pennsylvania	1907
Stanwood, James B. Cincinnati, Ohio.	Vice-President and Engineer, Houston, Stanwood & Gamble Company	1894
Steel, Alvin A. Fayetteville, Ark.	Assistant Professor of Geology and Mining, University of Arkansas	1905

Name and Address.	Title.	Date of Membership.
Stewart, Louis B. .... Toronto, Ontario.	Lecturer in Surveying, School of Practical Science.........	1897
Stoek, Harry H. .... 809 Quincy Ave., Scranton, Pa.	Editor, *Mines and Minerals*, International Textbook Co.	1907
Stout, Oscar V. P. .... Lincoln, Neb.	Professor of Civil Engineering, University of Nebraska............	1894
Strong, Frank........... Lawrence, Kan.	Chancellor, University of Kansas....	1907
Stubbs, Joseph E. .... Reno, Nev.	President, Nevada State University..	1897
Swain, George F. .... Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology....	1893
Swift, Walter........... Sheffield, England.	Secretary of Technical Department, University College	1902
Talbot, Arthur N. .... Urbana, Ill.	Professor of Municipal and Sanitary Engineering, University of Illinois..	1893
Talbot, Henry P. .... Boston, Mass.	Professor of Analytical Chemistry, Massachusetts Institute of Technology	1903
Taylor, Thomas U. .... Austin, Tex.	Professor of Civil Engineering, University of Texas...............	1902
Taylor, William D. ...... Chicago, Ill.	Chief Engineer, Chicago and Alton Railway Co.	1894
Thach, Charles C. .... Auburn, Ala.	President, Alabama Polytechnic Institute	1905
Thaler, Joseph A. .... Bozeman, Mont.	Professor of Electrical Engineering, Montana College of Agriculture and Mechanic Arts...................	1901
Thomas, Charles W. ..... West Raleigh, N. C.	Professor of Mechanical Engineering, The North Carolina College of Agriculture and Mechanic Arts.........	1904
Thomas, Robert G. .... Charleston, S. C.	Professor of Mathematics and Engineering, South Carolina Military Academy	1894
Thompson, William O. ... Columbus, Ohio.	President, Ohio State University.....	1907

Name and Address.	Title.	Date of Membership.
Thornburg, Charles L. ... South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University............	1894
Thorpe, John C. .... 203 W. Green St., Urbana, Ill.	Assistant Professor of Steam Engineering, University of Illinois......	1907
Timmerman, Arthur H. ... St. Louis, Mo.	Superintendent, Wagner Electric Mfg. Co.	1894
Titsworth, Alfred A. .... 590 George St., New Brunswick, N. J.	Professor of Civil Engineering and Graphics, Rutgers College..........	1895
Towle, William M. ...... 27 Main St., Potsdam, N. Y.	Superintendent of Shops, Clarkson School of Technology.....	1895
Townsend, Edgar J. ...... 516 John St., Champaign, Ill.	Professor of Mathematics, Dean of the College of Science, University of Illinois	19 6
Turneaure, Frederick E. . Madison, Wis.	Dean of the College of Engineering, University of Wisconsin...........	1894
Turner, Daniel L. .... 220 W. 107th St., New York, N. Y.	General Inspector of Stations, Board of Rapid Transit Commissions, New York City........................	1898
Turner, William P. ...... Lafayette, Ind.	Professor of Practical Mechanics, Purdue University.................	1900
Turrill, Sherman M. ..... 4227 Hamilton Ave., Cincinnati, Ohio.	Instructor in Civil Engineering, University of Cincinnati...........	1903
Tyler, Harry W. .... 491 Boylston St., Boston, Mass .	Professor of Mathematics, Massachusetts Institute of Technology.......	1894
Van Hise, Charles R. ... Madison, Wis.	President, University of Wisconsin...	1904
Van Ness, L. G. .... 22 N. 2d St., Memphis, Tenn.	Secretary, Merchants' Power Co......	1907
Van Ornum, John L. ..... St. Louis, Mo.	Professor of Civil Engineering, Washington University............	1895
Vedder, Herman K. .... East Lansing, Mich.	Professor of Mathematics and Civil Engineering, Michigan Agricultural College	1894

Name and Address.	Title.	Date of Membership.
Vosskuehler, Joseph H. .. Madison, Wis.	Assistant Professor of Machine Design, University of Wisconsin......	1902
Votey, J. William .... Burlington, Vt.	Professor of Civil Engineering and Dean of Engineering Department, University of Vermont............	1902
Waddell, J. A. L. .... 608 New Nelson Bldg., Kansas City, Mo.	Consulting Bridge Engineer, Waddell and Harrington	1893
Wadsworth, Joel E. .... 22 Morsemere Place, Yonkers, N. Y.	Resident Engineer, American Bridge Co.	1895
Wadsworth, M. Edward .. State College, Pa.	Dean of School of Mines and Metallurgy and Professor of Mining and Geology, Pennsylvania State College.	1895
Wait, John Cassan...... 3607 Broadway, New York, N. Y.	Attorney-at-Law, Wait & Foster.....	1907
Waldo, Clarence A. ...... Lafayette, Ind.	Head Professor of Mathematics, Purdue University.................	1897
Walker, Elton D. .... State College, Pa.	Professor of Hydraulic and Sanitary Engineering, Pennsylvania State College	1895
Wallace, Jacob H. .... Boulder, Colo.	Instructor in Engineering Drawing, University of Colorado............	1905
Wallace, John F. .... 355 Dearborn St., Chicago, Ill.	Consulting Engineer	1903
Ward, Kenneth B. .... Columbus, Ohio.	Assistant in Civil Engineering, Ohio State University.............	1907
Waterbury, Leslie A. .... Tucson, Ariz.	Professor of Civil Engineering, University of Arizona.............	1906
Webb, J. Burkitt......... Hoboken, N. J.	Consulting Engineer in Mathematics, Mechanics and Physics............	1906
Webber, Roy I. .... State College, Pa.	Assistant Professor of Structural Engineering, Pennsylvania State College	1907
Wessling, Albert G. ..... 549 Milton St., Cincinnati, Ohio.	Assistant Engineer, Bullock Electric Mfg. Co., Electrical Department, Allis-Chalmers Co.	1907

Name and Address.	Title.	Date of Membership.
Whipple, George C. 220 Broadway, New York, N. Y.	Consulting Engineer, Firm of Hazen and Whipple	1896
White, James M. Champaign, Ill.	Professor of Architectural Engineering and Supervising Architect, University of Illinois	1900
Wiley, William O. 43 and 45 E. 19th St., New York, N. Y.	Publisher of Scientific Books, Secretary, John Wiley and Sons	1904
Willard, Arthur C. 1813 13th St., N. W., Washington, D. C.	Assistant Professor of Mechanical Engineering, George Washington University	1907
Williams, Frank B. Schenectady, N. Y.	Professor of Engineering Mathematics, Union University	1901
Williams, Gardner S. 1503 Washtenaw Ave., Ann Arbor, Mich.	Professor of Civil, Hydraulic and Sanitary Engineering, University of Michigan	1907
Williams, Joseph D. 206 West St., Worcester, Mass.	Instructor in Civil Engineering, Worcester Polytechnic Institute	1907
Williams, Sylvester N. Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College	1893
Williston, Arthur L. Brooklyn, N. Y.	Director, Department of Science and Technology, Pratt Institute	1897
Wilmore, John J. Auburn, Ala.	Professor of Mechanical Engineering, Alabama Polytechnic Institute	1894
Wilson, Delonza T. Cleveland, Ohio.	Assistant Professor of Mathematics and Astronomy, Case School of Applied Science	1907
Withrow, James R. Columbus, Ohio.	Assistant Professor of Chemistry, Ohio State University	1907
Wolcott, Edson Ray Joliet, Ill.	With Rankin Chemical Reduction Company	1906
Wood, Arthur J. State College, Pa.	Assistant Professor of Experimental Engineering, Pennsylvania State College	1898
Woodbridge, Samuel H. Boston, Mass.	Associate Professor of Heating and Ventilation, Massachusetts Institute of Technology	1904

Name and Address.	Title.	Date of Membership.
Woodward, Calvin M. .... St. Louis, Mo.	Professor of Mathematics and Applied Mechanics and Dean of the School of Engineering and Architecture, Washington University	1894
Woodward, Robert S. ...... 1513 Sixteenth St., Washington, D. C.	President, Carnegie Institution, Washington, D. C.	1894
Wrentmore, Clarence G. . 933 Forest Ave., Ann Arbor, Mich.	Assistant Professor of Civil Engineering, University of Michigan........	1904
Young, Gilbert A. .... 409 University Ave., W. Lafayette, Ind.	Assistant Professor of Mechanical Engineering, Purdue University....	1907
Young, Lewis E. .... Golden, Colo.	Professor of Mining, Colorado School of Mines	1903
Zeleny, Anthony......... 321 Church St., S. E., Minneapolis, Minn.	Assistant Professor of Physics, University of Minnesota...........	1907
Zimmerman, Oliver B. .... Charles City, Iowa.	Mechanical Engineer and Chief Draftsman, Hart-Parr Co.	1902
Ziwet, Alexander......... Ann Arbor, Mich.	Professor of Mathematics, University of Michigan............	1897

GEOGRAPHICAL DISTRIBUTION OF MEMBERS.

Names in italics are those of persons not engaged in teaching.

Alabama.—Auburn; B. H. Crenshaw; G. N. Mitcham; C. C. Thach; J. J. Wilmore. (4.) **Montevallo;** T. W. Palmer. (1.) **Talladega;** *H. H. Kyser.* (1.) **University;** E. B. Kay; E. J. McCaustland. (2.)

Arizona.—Tucson; W. W. Henley; L. A. Waterbury. (2.)

Arkansas.—Fayetteville; W. M. Gladson; J. J. Knoch; A. A. Steel. (3.)

California.—Berkeley; S. B. Christy; C. Derleth, Jr.; H. W. Reynolds. (3.) **Pasadena;** H. T. Clifton. (1.) **Stanford University;** W. F. Durand; L. M. Hoskins; C. D. Marx; H. J. Ryan. (4.)

Colorado.—Boulder; H. S. Evans; J. A. Hunter; D. R. Jenkins; M. S. Ketchum; J. H. Wallace. (5.) **Colorado Springs;** F. Cajori. (1.) **Golden;** V. C. Alderson; C. R. Burger; L. E. Young. (3.) **Ft. Collins;** L. S. Carpenter; J. W. Lawrence. (2.)

Connecticut.—New Haven; S. E. Barney, Jr.; A. J. DuBois. (2.)

Delaware.—Newark; F. H. Robinson. (1.)

District of Columbia.—Washington; (Carnegie Institution.) R. S. Woodward. (1.) (George Washington Univ.) A. C. Willard. (1.) (City.) *P. Betts; B. R. Green; J. F. Hayford; E. Mead; D. A. Molitor.* (5.)

Florida.—Gainesville; J. R. Benton. (1.) **Lake City;** N. H. Cox. (1.)

Georgia.—Athens; A. H. Patterson. (1.) **Dahlonega;** J. F. O'Byrne. (1.)

Illinois.—Champaign; I. O. Baker; H. F. Moore; L. G. Parker; E. J. Townsend; J. M. White. (Univ. of Ill.) **Chicago;** (Armour Inst.) R. Burnham; C. E. Freeman; L. C. Monin; A. A. Radtke; H. M. Raymond. (5.) (Lewis Inst.); A. Moseley. (1.) (University.) C. Kinsley. (1.) (City.) *B. J. Arnold; O. Bates; A. Bement; W. H. Bixby; G. M. Brill; W. M. Camp; O. Chanute; A. S. Hibbard; G. F. Horton; G. H. Rowe; R. L. Short; W. D. Taylor; J. F. Wallace.* (13.) **Decatur;** H. E. Smith. (1.) **Evanston;** A. W. Harris. (1.) **Joliet;** *E. R. Wolcott.* (1.) **Kankakee;** F. G. Frink. (1.) **Peoria;** F. L. Bishop; F. H. Evans. (2.) **Urbana;** L. P. Breckenridge; J. P. Brooks; M. Brooks; F. O. Dufour; J. H. Gill; G. A. Goodenough; W. F. M. Goss; C. T. Knipp; O. A. Leutwiler; N. C. Ricker; E. C. Schmidt; A. N. Talbot; J. C. Thorpe. (13+5=18.)

Indiana.—Lafayette; C. H. Benjamin; S. Coulter; L. E. Endsley; J. W. Esterline; H. O. Garman; E. L. Hancock; W. K. Hatt; J. D. Hoffman; C. H. Lawrance; L. V. Ludy; C. P. Matthews; H. T. Plumb; J. H. Ransom; W. P. Turner; C. A. Waldo; G. A. Young.

(16.) (City.) *M. Price.* (1.) **Richmond;** W. C. McNown. (1.) **Terre Haute;** T. Gray; M. A. Howe; C. L. Mees. (3.)

Iowa.—Ames; S. W. Beyer; F. A. Fish; A. H. Hoffman; A. Marston; W. H. Meeker; L. B. Spinney. (6.) **Charles City;** *O. B. Zimmerman.* (1.) **Iowa City;** A. H. Ford; F. G. Higbee; B. J. Lambert; C. S. Magowan; E. L. Ohle; W. G. Raymond. (6.) **Mt. Vernon;** S. N. Williams. (1.)

Kansas.—Lawrence; F. O. Marvin; F. Strong. (2.)

Kentucky.—Lexington; F. P. Anderson. (1.)

Louisiana.—Baton Rouge; A. M. Herget. (1.) **Breaux Bridge;** *A. C. Love.* (1.) **New Orleans;** D. S. Anderson; W. H. Creighton; W. B. Gregory; H. F. Rugan. (4.)

Maine.—Orono; H. S. Boardman. (1.)

Massachusetts.—Amherst; J. E. Ostrander. (1.) **Boston;** (Mass. Inst.) C. L. Adams; C. F. Allen; C. B. Breed; A. E. Burton; H. W. Hayward; H. O. Hofman; D. C. Jackson; W. H. James; G. Lanza; D. Porter; R. H. Richards; A. G. Robbins; W. T. Sedgwick; G. F. Swain; H. P. Talbot; H. W. Tyler; S. H. Woodbridge. (17+4=21.) (Y. M. C. A.) A. D. Dean. (1.) (City.) *H. K. Barrows; J. P. Munroe.* (2.) **Brookline;** W. E. Mott. (M. I. T.) **Cambridge;** C. A. Adams, Jr.; I. N. Hollis; E. V. Huntington; L. J. Johnson; F. L. Kennedy; H. L. Smyth. (6.) **Dorchester;** J. H. Hawes. (1.) **E. Bridgewater;** *C. A. Chandler.* (1.) **Newton Centre;** H. E. Clifford. (M. I. T.) **Newtonville;** L. E. Moore. (M. I. T.) **Stoneham;** C. H. Chase. (T. C.) **Taunton;** C. F. Parks. (M. I. T.) **Tufts College;** G. C. Anthony; C. D. Bray. (2+1=3.) **Watertown;** *W. B. Snow.* (1.) **Worcester;** C. M. Allen; E. A. Engler; H. P. Fairfield; A. W. French; H. C. Ives; C. D. Knight; J. O. Phelon; A. S. Richey; A. L. Smith; H. B. Smith; J. D. Williams. (11.)

Michigan.—Ann Arbor; J. R. Allen; M. E. Cooley; C. S. Denison; W. S. Hazelton; W. L. Miggett; H. C. Sadler; G. S. Williams; C. G. Wrentmore; A. Ziwet. (9.) **Calumet;** *J. MacNaughton.* (1.) **East Lansing;** G. W. Bissell; A. R. Sawyer; H. K. Vedder. (3.) **Houghton;** L. S. Austin; G. L. Christensen; D. Copeland; F. W. Denton; J. Fisher, Jr.; E. D. Grant; O. P. Hood; F. W. McNair; F. W. Sperr. (9.) **Ishpeming;** *M. M. Duncan.* (1.) **Lapeer;** *F. Morley.* (1.) **Marquette;** *J. M. Longyear.* (1.) **Vulcan;** *W. Kelly.* (1.)

Minnesota.—Minneapolis; F. H. Bass; W. E. Brooke; F. H. Constant; Henry T. Eddy; J. J. Flather; G. B. Frankforter; B. F. Groat; A. E. Haynes; F. S. Jones; W. H. Kavanaugh; G. D. Shepardson; C. F. Shoop; F. W. Springer; A. Zeleny. (14.)

Mississippi.—University; H. L. Drane; A. Hume; J. W. Johnson. (3.)

Missouri.—Columbia; L. M. Defoe; A. L. Hyde; T. J. Rodhouse; H. B. Shaw; F. P. Spalding. (5.) **Kansas City**; (High School.) J. M. Kent. (1.) (City.) *J. L. Harrington; I. G. Hedrick; A. Maitland, Jr.; W. K. Palmer; J. A. L. Waddell.* (5.) **Rolla**; E. G. Harris; G. E. Ladd. (2.) **St. Louis**; (High School.) S. H. Moore. (1.) (Washington Univ.) A. S. Langsdorf; J. L. Van Ornum; C. M. Woodward. (3.) (City.) *A. H. Timmerman.* (1.)

Montana.—Bozeman; J. A. Thaler. (1.) **Helena**; *J. S. Baker.* (1.)

Nebraska.—Lincoln; G. R. Chatburn; E. W. Davis; G. H. Morse; C. Russ Richards; T. B. Sears; O. V. P. Stout. (6.) **Scottsbluff**; *J. A. Green.* (1.)

Nevada.—Reno; J. G. Scrugham; J. E. Stubbs. (2.)

New Hampshire.—Durham; A. F. Nesbit; C. H. Pettee. (2.) **Hanover**; R. Fletcher; J. V. Hazen; C. A. Holden. (3.)

New Jersey.—East Orange; *N. C. Grover.* (1.) **Hoboken**; (Stevens Institute.) J. E. Denton; F. D. Furman; A. F. Ganz; A. C. Humphreys; L. A. Martin, Jr.; W. A. Shoudy. (6.) (City.) *J. B. Webb.* (1.) **Newark**; *E. J. Kunze.* (1.) **New Brunswick**; A. A. Titsworth. (1.) **Princeton**; H. S. S. Smith. (1.) **Wyckoff**; *W. H. Browne, Jr.* (1.)

New York.—Brooklyn; (Polytechnic Inst.) F. W. Atkinson; W. D. Ennis; S. Sheldon; C. M. Spofford. (4.) (Pratt Inst.) S. S. Edmands; J. M. Jameson; W. J. Kaup; E. H. Koch, Jr.; A. L. Williston. (5.) F. B. Abbott. (Columbia.) (City.) *W. B. Russell.* (1.) **Ithaca**; F. A. Barnes; R. C. Carpenter; I. A. Colby; C. L. Crandall; E. E. Haskell; H. W. Hibbard; H. S. Jacoby; G. S. Macomber; H. H. Norris. $(9 + 1 = 10.)$ **Homer**; H. A. Gehring. (Cornell Univ.) **New York**; (Carnegie Foundation.) H. S. Pritchett. (1.) (Columbia Univ.) A. Black; W. H. Burr; F. A. Goetze; F. R. Hutton; C. E. Lucke; C. E. Morrison; H. S. Munroe; M. I. Pupin; W. Rautenstrauch; C. Russell Richards; G. F. Sever. $(11+1=12.)$ (Cooper Union.) W. A. Anthony. (1.) (Manhattan Auto. School.) F. R. Jones. (1.) (Mech'cs' Inst.) L. Rouillion. (1.) (N. Y. Univ.) C. H. Snow. (1.) (City.) *M. R. Bump; E. Caldwell; E. L. Corthell; H. L. Doherty; Louis Duncan; E. S. Farwell; A. E. Foyé; A. H. Frost; H. P. Gillette; F. A. Halsey; D. S. Jacobus; B. Jones, Jr.; C. Kirchhoff; M. Merriman; D. E. Moran; J. A. Moyer; F. W. Parsons; D. L. Turner; J. C. Wait; G. C. Whipple; W. O. Wiley.* (21.) **Potsdam**; W. S. Aldrich; B. B. Brackett; W. M. Towle. (3.) **Schenectady**; J. W. Hughes; O. H. Landreth; F. B. Williams. (3.) **Syracuse**; (Univ.) W. Kent. (1.) (City.) *J. H. Barr.* (1.) **Troy**; A. M. Greene, Jr. (1.) **Wellsville**; *C. V. Kerr.* (1.) **Yonkers**; *J. S. Brown; J. E. Wadsworth.* (2.)

North Carolina.—W. Raleigh; C. W. Thomas. (1.)

North Dakota.—Agricultural College; R. H. Slocum. (1.) **Grand Forks**; E. J. Babcock; E. F. Chandler. (2.)

Ohio.—Cincinnati; (Univ. of Cincinnati.) J. T. Faig; A. L. Jenkins; H. Schneider; S. E. Slocum; S. M. Turrill. (5.) (City.) *Horace T. Eddy; J. B. Stanwood; A. G. Wessling.* (3.) **Cleveland**; (Case School.) H. B. Dates; R. G. Dukes; R. H. Fernald; T. M. Focke; C. S. Howe; C. F. Mabery; D. C. Miller; F. H. Neff; C. E. Reid; A. W. Smith; D. T. Wilson. (11.) (City.) *F. W. Ballard; H. M. Lane; G. Smart.* (3.) **Columbus**; (O. S. U.) R. D. Bohannan; J. E. Boyd; J. N. Bradford; F. C. Caldwell; F. H. Eno; T. E. French; E. A. Hitchcock; H. Judd; W. A. Knight; N. W. Lord; W. T. Magruder; C. T. Morris; E. Orton, Jr.; F. A. Ray; S. W. Robinson; F. E. Sanborn; C. E. Sherman; W. O. Thompson; K. B. Ward; J. R. Witherow. (20.) **Dayton**; *R. S. King.* (1.)

Pennsylvania.—Allegheny; D. Carhart. (1.) C. B. Connelley. (C. T. S.) **Altoona**; *C. B. Dudley.* (1.) **Bethlehem**; W. S. Franklin. (Lehigh.) **Easton**; J. M. Porter. (1.) **E. Pittsburg**; *A. Kingsbury.* (1.) **Haverford**; L. H. Rittenhouse. (1.) **Lewisburg**; C. A. Lindeman. (1.) **Philadelphia**; (Central M. T. H. School.) L. F. Rondinella. (1.) (Drexel Inst.) A. J. Rowland; E. B. Smith. (2.) (Univ. of Pa.) E. Marburg; H. W. Spangler; J. V. Stanford. (3.) (City.) *A. W. Ayer; L. M. Haupt; T. Olsen.* (3.) **Pittsburg**; (Carnegie Tech. Sch.) A. A. Hamerschlag; F. E. Foss; C. C. Leeds. (3 + 1 = 4.) (City.) *C. F. Scott.* (1.) **Scranton**; J. J. Clark; E. H. Powell. (2.) (City.) *H. H. Stoek.* (1.) **South Bethlehem**; H. S. Drinker; W. Esty; P. A. Lambert; F. P. McKibben; C. L. Thornburg. (5 + 1 = 6.) **State College**; W. S. Ayars; H. Diemer; J. P. Jackson; C. P. Linville; R. E. Myers; H. B. Shattuck; M. E. Wadsworth; E. D. Walker; R. I. Webber; A. J. Wood. (10.) **Wilkinsburg**; *H. W. Brown; C. R. Dooley.* (2.)

Rhode Island.—Providence; A. H. Blanchard; J. A. Brooks; J. E. Hill; W. H. Kenerson; C. M. Phetteplace; O. E. Randall. (6.)

South Carolina.—Charleston; R. G. Thomas. (1.) **Clemson College**; W. M. Riggs. (1.)

South Dakota.—Brookings; H. B. Mathews; H. C. Solberg. (2.) **Vermillion**; A. B. MacDaniel. (1.)

Tennessee.—Knoxville; B. Ayres; W. W. Carson. (2.) **Memphis**; *L. G. Van Ness.* (1.) **Nashville**; W. H. Schuerman. (1.) **Sewanee**; S. M. Barton. (1.)

Texas.—Austin; H. Y. Benedict; A. C. Scott; T. U. Taylor. (3.) **College Station**; N. H. Brown; E. J. Fermier; F. E. Giesecke; J. C. Nagle; C. Puryear. (5.)

Utah.—Logan; J. Jenson. (1.) **Provo**; *P. N. Nunn.* (1.) **Salt Lake City**; J. F. Merrill. (1.)

Vermont.—Burlington; W. H. Freedman; C. H. Pierce; E. Robinson; J. W. Votey. (4.)

Virginia.—Blacksburg; L. S. Randolph. (1.) **Lexington**; D. C. Humphreys. (1.)

Washington.—Pullman; W. J. Roberts. (1.) **Seattle**; C. E. Fowler; A. H. Fuller; G. I. Gavett; E. Haviland, Jr.; C. E. Magnusson; C. C. More; F. A. Osborn. (7.)

West Virginia.—Morgantown; W. H. Boughton; F. L. Emory; C. R. Jones; F. L. Kortright. (4.)

Wisconsin.—Beloit; *A. T. Bruegel.* (1.) **Madison**; M. C. Beebe; S. Bull; C. F. Burgess; J. G. D. Mack; E. R. Maurer; A. V. Millar; W. D. Pence; J. D. Phillips; L. E. Reber; A. W. Richter; J. W. Shuster; C. S. Slichter; L. S. Smith; F. E. Turneaure; C. R. Van Hise; J. H. Vosskuehler. (16.) **Milwaukee**; *G. H. Benzenberg.* (1.)

Australia.—Sydney, N. S. W.; S. H. Barraclough. (1.)

Canada.—Montreal, Quebec; H. T. Bovey; R. B. Owens; J. B. Porter. (3.) **Toronto, Ontario**; J. Galbraith; T. R. Rosebrugh; L. B. Stewart. (3.) **Winnipeg, Manitoba**; E. E. Brydone-Jack. (1.)

England.—London; *T. C. Mendenhall.* (1.) **Sheffield**; W. Swift. (1.)

GEOGRAPHICAL SUMMARY OF MEMBERS.

Alabama	8	Maine	1	Rhode Island	3
Arizona	2	Massachusetts	48	South Carolina	2
Arkansas	3	Michigan	26	South Dakota	3
California	8	Minnesota	14	Tennessee	5
Colorado	11	Mississippi,	3	Texas	8
Connecticut	2	Missouri	18	Utah	3
Delaware	1	Montana	2	Vermont	4
District of Columbia	7	Nebraska	7	Virginia	2
Florida	2	Nevada	2	Washington	8
Georgia	2	New Hampshire	5	West Virginia	4
Illinois	44	New Jersey	12	Wisconsin	18
Indiana	21	New York	70	Australia	1
Iowa	14	North Carolina	1	Canada	7
Kansas	2	North Dakota	3	England	2
Kentucky	1	Ohio	43		
Louisiana	6	Pennsylvania	41	Total	503

INSTITUTIONS REPRESENTED.

	Members.	No.
Massachusetts Institute of Technology	21	1.
Ohio State University	20	1.
University of Illinois	18	1.
Purdue University	16	
University of Wisconsin	16	2.
University of Minnesota	14	1.
Columbia University	12	1.
Case School of Applied Science	11	
Worcester Polytechnic Institute	11	2.
Cornell University	10	
Pennsylvania State College	10	2.
Michigan College of Mines	9	
University of Michigan	9	2.
University of Washington	7	1.
Brown University	6	
Harvard University	6	
Iowa State College	6	
State University of Iowa	6	
Lehigh University	6	
University of Nebraska	6	
Stevens Institute of Technology	6	7.
Armour Institute	5	
University of Cincinnati	5	
University of Colorado	5	
University of Missouri	5	
Pratt Institute	5	

	Members.	No.
Agricultural and Mechanical College of Texas	5	6.
Alabama Polytechnic Institute	4	
Polytechnic Institute of Brooklyn	4	
Carnegie Technical School	4	
Leland Stanford Junior University	4	
Tulane University	4	
University of Vermont	4	
University of West Virginia	4	7.
University of Arkansas	3	
University of California	3	
Clarkson School of Technology	3	
Colorado School of Mines	3	
McGill University	3	
Michigan Agricultural College	3	
University of Mississippi	3	
University of Pennsylvania	3	
Rose Polytechnic Institute	3	
University of Texas	3	
Thayer School of Civil Engineering of Dartmouth College	3	
Toronto School of Applied Science	3	
Tufts College	3	
Union University	3	
Washington University	3	15.
University of Alabama	2	
University of Arizona	2	
Bradley Polytechnic Institute	2	
Colorado State Agricultural College	2	
Drexel Institute	2	
University of the State of Florida	2	
International Correspondence Schools	2	
University of Kansas	2	
Missouri School of Mines and Metallurgy	2	
Nevada State University	2	
New Hampshire College of Agriculture and Mechanic Arts	2	
University of North Dakota	2	
South Dakota Agricultural College	2	
University of Tennessee	2	
Yale University	2	15.
Alabama Girls' Industrial School	1	
Bucknell University	1	
Carnegie Foundation for the Advancement of Teaching	1	
Carnegie Institution	1	
University of Chicago	1	
Clemson College	1	
Colorado College	1	

	Members.	No.
Cooper Union	1	
Cornell College	1	
Delaware College	1	
Dorchester High School	1	
Earlham College	1	
George Washington University	1	
University of Georgia	1	
Haverford College	1	
James Millikin University	1	
Kansas City High School	1	
State College of Kentucky	1	
Lafayette College	1	
Lewis Institute	1	
Louisiana State University	1	
University of Maine	1	
Manhattan Automobile School	1	
University of Manitoba	1	
Massachusetts Agricultural College	1	
New York Mechanics' Institute	1	
Montana College of Agriculture and Mechanic Arts	1	
New York University	1	
North Carolina College of Agriculture and Mechanic Arts	1	
North Georgia Agricultural College	1	
North Dakota Agricultural College	1	
Northwestern University	1	
Philadelphia Central Manual Training High School	1	
Princeton University	1	
Rensselaer Polytechnic Institute	1	
Rutgers College	1	
St. Louis McKinley High School	1	
University College, Sheffield	1	
University of the South	1	
South Carolina Military Academy	1	
University of South Dakota	1	
University of Sydney	1	
University of Syracuse	1	
Throop Polytechnic Institute	1	
State Agricultural College of Utah	1	
State School of Mines of Utah	1	
Vanderbilt University	1	
Virginia Polytechnic Institute	1	
Washington Agricultural College	1	
Washington and Lee University	1	
Western University of Pennsylvania	1	
Y. M. C. A. of Massachusetts and Rhode Island	1	52.

SUMMARY BY OCCUPATIONS.

	Teachers. 1906	Teachers. 1907	Practitioners. 1906	Practitioners. 1907
Architecture	3	3	1	0
Biology	2	2	0	0
Chemistry	3	8	2	2
Civil Engineering	82	102	22	34
Deans and Directors only	7	11	0	0
Drawing	16	16	0	0
Electrical Engineering	38	47	9	13
Journalists	..	0	..	9
Manual Training	8	4	0	0
Mathematics	36	38	1	2
Mechanical Engineering	69	81	17	18
Mechanics	13	15	0	0
Metallurgy	5	6	0	0
Mining Engineering	14	14	7	6
Physics	13	24	0	0
Presidents	20	15	0	0
Shopwork	3	10	0	0
Trade-school	1	5	0	0
Unclassified	9	8	14	10
Professors who are also Deans	..	(40)	..	..
Total	342	409	73	94

GENERAL SUMMARY

	1906.	1907.
Different Institutions represented:—		
Colleges and Universities teaching Engineering, Domestic.	85	94
Foreign...	6	5
Manual Training, High, Correspondence, and Trade Schools	13	17
Total Institutions	104	116
Teachers, and, in many cases, also practitioners	342	409
Practitioners, not teaching	73	94
Total Members	415	503

DECEASED MEMBERS.

Name.	Year of Election.	Date of Death.	Memoir. Vol.	Page.
George W. Atherton	1904	July 24, 1906.	XIV,	292
Volney G. Barbour	1894	June 4, 1901.	IX,	340
Charles B. Brush	1893	June 3, 1897.	VII,	181
Eckley B. Coxe	1894	May 13, 1895.	VII,	182
Thomas M. Drown	1895	Nov. 16, 1904.	XII,	244
Francis R. Fava, Jr.	1894	March 28, 1896.	VII,	183
Estevan A. Fuertes	1894	January 16, 1903.	XI,	372
Henry Fulton	1894	December 6, 1901.	X,	258
Herbert G. Geer	1894	March 7, 1900.	VIII,	371
Lyman Hall	1904	Aug. 16, 1905.	XIV,	287
Albert H. Heller	1903	Feb. 20, 1906.	XIV,	290
John B. Johnson	1893	June 23, 1902.	X,	259
Rodney G. Kimball	1894	April 25, 1900.	X,	261
Burton S. Lanphear	1897	October 14, 1904.	XII,	249
Benjamin F. La Rue	1899	Dec. 22, 1903.	XII,	243
Justus M. Silliman	1894	April 15, 1896.	VII,	184
James H. Stanwood	1894	May 24, 1896.	VII,	185
Robert H. Thurston	1893	October 25, 1903.	XII,	246
Alphonse N. Van Daell	1897	March 28, 1899.	VII,	186
John R. Wagner	1894	January 21, 1899.	VII,	187
Francis A. Walker	1896	January 5, 1897.	VII,	188
Howard S. Webb	1897	June 12, 1905.	XIV,	286
Nelson O. Whitney	1893	March 17, 1901.	IX,	339
James R. Willett	1896	May 9, 1907.	XV,	679
De Volson Wood	1893	June 27, 1897.	V,	325

PAST OFFICERS.

Special Committee for Division E, Engineering Education, World's Engineering Congress, 1893.

IRA O. BAKER, Chairman, HENRY T. EDDY, Vice-Chairman,
WM. R. HOAG, Secretary, C. FRANK ALLEN, Sec'y, *pro tem.*,
MORTIMER E. COOLEY, SAMUEL W. STRATTON,
STORM BULL.*

PRESIDENTS.

DE VOLSON WOOD,* 1893–4,
GEORGE F. SWAIN, 1894–5,
MANSFIELD MERRIMAN, 1895–6,
HENRY T. EDDY, 1896–7,
JOHN B. JOHNSON,* 1897–8,
THOS. C. MENDENHALL, 1898–9,
IRA O. BAKER, 1899–1900,
FRANK O. MARVIN, 1900–1,
ROBERT FLETCHER, 1901–2,
CALVIN M. WOODWARD, 1902–3,
C. FRANK ALLEN, 1903–4,
FRED W. McNAIR, 1904–5,
CHARLES L. CRANDALL, 1905–6,
DUGALD C. JACKSON, 1906–7.

VICE-PRESIDENTS.

SAMUEL B. CHRISTY, GEORGE F. SWAIN, 1893–4,
ROBERT H. THURSTON,* FRANK O. MARVIN, 1894–5,
FRANK O. MARVIN, CADY STALEY, 1895–6,
JOHN GALBRAITH, JOHN M. ORDWAY, 1896–7,
THOMAS C. MENDENHALL, HARRY W. TYLER, 1897–8,
C. FRANK ALLEN, HENRY W. SPANGLER, 1898–9,
ROBERT FLETCHER, CHARLES D. MARX, 1899–1900,
THOMAS GRAY, ALBERT KINGSBURY, 1900–1,
STORM BULL,* CALVIN M. WOODWARD, 1901–2,
JOHN J. FLATHER, FRED W. McNAIR, 1902–3,
CHARLES L. CRANDALL, JAMES C. NAGLE, 1903–4,
CLEMENT R. JONES, ELWOOD MEAD, 1904–5,
WILLIAM T. MAGRUDER, JOHN P. JACKSON, 1905–6.
ROLLA C. CARPENTER, CHARLES S. HOWE, 1906–7.

TREASURERS.

STORM BULL,* 1893–5,
JOHN J. FLATHER, 1895–9,
CLARENCE A. WALDO, 1899–1902,
ARTHUR N. TALBOT, 1902–4,
FRED. P. SPALDING, 1904–6,
ANSON MARSTON, 1906–7.

SECRETARIES.

JOHN B. JOHNSON,* 1893–5,
C. FRANK ALLEN, 1895–7,
ALBERT KINGSBURY, 1897–9,
EDGAR MARBURG, 1899–1900,
HENRY S. JACOBY, 1900–2,
CLARENCE A. WALDO, 1902–4,
MILO S. KETCHUM, 1904–6,
WILLIAM T. MAGRUDER, 1906–7.

* Deceased.

MEMBERS OF PREVIOUS COUNCILS.

Terms of Office Expired in 1894.

M. E. COOLEY, H. T. EDDY, W. F. M. GOSS,
W. R. HOAG, S. W. ROBINSON, H. W. SPANGLER,
R. H. THURSTON.*

Terms of Office Expired in 1895.

H. T. BOVEY, W. H. BURR, O. H. LANDRETH,
MANSFIELD MERRIMAN, W. G. RAYMOND, G. F. SWAIN,
DE VOLSON WOOD.*

Terms of Office Expired in 1896.

I. O. BAKER, STORM BULL,* S. B. CHRISTY,
JOHN GALBRAITH, J. B. JOHNSON,* F. O. MARVIN,
C. D. MARX.

Terms of Office Expired in 1897.

H. T. EDDY, J. J. FLATHER, J. P. JACKSON,
ALBERT KINGSBURY, L. S. RANDOLPH, S. W. ROBINSON,
R. H. THURSTON.*

Terms of Office Expired in 1898.

C. F. ALLEN, C. L. MEES, MANSFIELD MERRIMAN,
J. M. ORDWAY, W. G. RAYMOND, CADY STALEY,
R. S. WOODWARD.

Terms of Office Expired in 1899.

ARTHUR BEARDSLEY, ROBERT FLETCHER, JOHN GALBRAITH,
WILLIAM KENT, T. C. MENDENHALL, W. H. SCHUERMAN,
M. E. WADSWORTH.

Terms of Office Expired in 1900.

STORM BULL,* L. G. CARPENTER, ALBERT KINGSBURY,
F. O. MARVIN, R. B. OWENS, R. L. SACKETT,
R. H. THURSTON.*

Terms of Office Expired in 1901.

T. M. DROWN,* M. A. HOWE, I. N. HOLLIS,
GAETANO LANZA, P. C. RICKETTS, R. G. THOMAS,
C. M. WOODWARD.

Terms of Office Expired in 1902.

BROWN AYRES, G. W. BISSELL, J. J. FLATHER,
W. T. MAGRUDER, F. W. MCNAIR, J. M. PORTER,
A. J. WOOD.

Terms of Office Expired in 1903.

C. F. ALLEN, D. C. JACKSON, N. C. RICKER,
J. P. BROOKS, EDGAR MARBURG, A. L. WILLISTON,
J. C. NAGLE.

Terms of Office Expired in 1904.

W. F. M. GOSS, THOMAS GRAY, D. C. HUMPHREYS,
O. H. LANDRETH, W. G. RAYMOND, L. E. REBER,
L. S. RANDOLPH.

Terms of Office Expired in 1905.

WM. ESTY, L. J. JOHNSON, W. M. TOWLE,
H. S. JACOBY, ELWOOD MEAD, J. L. VAN ORNUM,
EDWARD ORTON, JR.,

Terms of Office Expired in 1906.

JOHN GALBRAITH, CHARLES S. HOWE, WALTER M. RIGGS,
FREDERICK P. SPALDING, HENRY W. SPANGLER, FRED. E, TURNEAURE,
HERMAN K. VEDDER.

Terms of Office Expired in 1907.

THOMAS GRAY, JAMES C. NAGLE, WILLIAM G. RAYMOND,
LOUIS E. REBER, ARTHUR N. TALBOT, CLARENCE A. WALDO,
ROBERT S. WOODWARD.

* Deceased.

CONSTITUTION

OF THE

Society for the Promotion of Engineering Education

1. Name.—This organization shall be called the Society for the Promotion of Engineering Education.

2. Members.—Members of the Society shall be those who occupy, or have occupied, responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. In taking this ballot, the Secretary is directed to close the polls one month after the names of the candidates are sent out. Councilors not heard from will be counted in favor of the candidate. Honorary Members shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

Life Members of the Society shall be those members not in arrears who have paid Fifty Dollars into the Treasury of the Society at one time.

The name of each candidate for membership shall be proposed in writing to the Council by two members to whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting; or, during the period between annual meetings, the Secretary may at any time submit to the council the names of candidates with the names of their sponsors. An affirmative letter ballot of three-fourths of those whose vote reaches the Secretary within one month of the time of sending out the names of candidates will suffice to elect. Such elections shall be credited to the previous annual meeting, and dues will date from that time.

3. Officers.—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year. They shall be chosen by vote of the members at the annual meeting.

4. Council.—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the Past Presidents of the Society shall be members of the Council *ex officiis*.

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society, at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, elect candidates *ad interim*, attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

5. Nominating Committee.—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five.

6. Fees and Dues.—The admission fee, which shall also include the first year's dues, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who shall be in arrears more than two years and shall have been duly notified by the Secretary, shall be thereby dropped from the roll, excepting such arrearages shall be paid previous to the next ensuing annual meeting; and no such member shall be restored until he has paid his arrears.

7. Meetings.—There shall be a regular meeting occurring at

the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the National Engineering Societies, or otherwise as the Council may determine.

8. Publications.—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. Amendments.—This Constitution may be amended by a two-thirds vote at any regular meeting, the amendment having been approved by a two-thirds vote of the Council, taken by letter ballot.

RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange the time and place of the annual meeting, and also to prepare a program for the same.

Second. The President, Secretary and Treasurer shall constitute an Executive Committee, which shall have charge of all matters relating to the business affairs of the Society not otherwise provided for.

Third. The reading of papers shall be limited to fifteen minutes each, and abstracts of the same of about three hundred words or less shall be printed when practicable and distributed in advance to the members.

Fourth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

PUBLICATIONS.

The publications of the Society can be obtained from the Secretary. The current issues are distributed gratuitously to members in good standing. The price of the bound volumes of the Proceedings is $2.50 to non-members, $2.00 to public libraries, and $1.50 to members for their libraries.

Reprints of papers may be ordered when the paper is in type form, and either with or without covers, at a price depending upon the number of pages and copies desired.

Report of the Proceedings.

Monday, July 1, 1907.

afternoon session, 1:30 o'clock.

The fifteenth annual meeting of the Society for the Promotion of Engineering Education was held in the lecture room of the Physics Building of the Case School of Applied Science, Cleveland, Ohio, July 1 to 3, 1907.

The meeting was called to order by the President, Dugald C. Jackson, who presided throughout the convention. President Chas. S. Howe of the Case School of Applied Science spoke words of welcome.

The report of the Secretary, William T. Magruder, was read and accepted.

Report of the Secretary, 1906–07.

To the Members of the Society,

Gentlemen:—Your secretary wishes to congratulate the membership on the prosperous growth and healthy condition of our Society. Viewed from any position we have reason to be greatly encouraged.

At the Ithaca Meeting, the secretary reported 400 members. Nineteen were then added by election by the Society. The ten following persons were elected to membership by letter-ballot of the Council in February, 1907:—Messrs. Murray C. Beebe, Harry Y. Benedict, Frederick A. Goetze, Bernard R. Green, Edward V. Huntington, Franklin A. Ray, Leon H.

Rittenhouse, James G. Scrugham, Stephen E. Slocum, and Edgar J. Townsend. The gross increase in membership for 1906 was therefore 29. So far as known, death has twice entered our ranks during the year. Dr. George W. Atherton, President of the Pennsylvania State College, died on July 24, 1906. His obituary is published on page 292 of Volume XIV of our Proceedings. Major James R. Willett died May 9, 1907. The name of Dr. Lyman Hall, President of the Georgia School of Technology, has also been removed from our roll by his death in 1905. The name of Chas. H. Wheeler of the Drexel Institute has been dropped. His present address is unknown to his friends, his alma mater and his ex-colleagues. Five members have resigned. The number of members enrolled at the beginning of this meeting is 415.

A number of other members should have been dropped for non-payment of dues, but in the absence of records of due notice having been sent to them, it was thought best by your secretary not to administer the constitution too severely and rigidly. If any member has not received his 1906 Volume of the Proceedings, it may be because it has been sent to his last-known address, rather than to his present address, or because he is in arrears for dues more than one year. He should read Section 6 of the Constitution, and interview the treasurer before he forces upon the secretary the ungracious but lawful act of dropping him. Due notice having been sent to each member in arrears more than one year, the enforcement of the law of the Society must be hereafter expected. It would seem that to allow a member to be in arrears for three full years, or for $9.00 before he can be dropped from the roll, is not crowding him. It demands of the treasurer and secretary extra labor and expense to save him the trouble of drawing a check, or of promptly paying up his back dues and resigning, or of asking to be dropped. Is not the Society too lax in this rule?

The secretary will appreciate it if the members will please remember that he is not endowed with omniscience, and if

they will promptly notify him of changes in their address and title. In one case, an error was not discovered for three years, or until it had been printed and presented to the member no less than nine times. While the secretary probably makes his share of mistakes, he is not responsible for all that have been made. Twenty-three changes in title or address have been received in the last three weeks, and since Volume XIV was printed. Some changes necessitate a dozen changes in the List of Members and the Summaries.

It may be of interest to note that we still have no members residing in the states of Idaho, North Dakota, Oklahoma, Oregon, and Wyoming, and in Arizona, New Mexico and the Indian Territories. We have but one member in each of the seven states, Delaware, Georgia, Kansas, Kentucky, Maine, Maryland, and Utah.

At the meeting of the council, held at Ithaca after the adjournment of the last annual meeting, the secretary was requested to make a thorough canvas of the engineering colleges, schools and practitioners, for new members. The subject was discussed by correspondence by the members of the executive committee. It was decided to send a personal letter with a copy of the List of Members of the Society and the Constitution, a membership application blank and a stamped addressed envelope to those teachers of engineering subjects who were not members of the Society, and to a carefully selected list of practitioners. This was done, and some 1500 letters sent to the teachers, and over 1000 to practising engineers. The replies have been most cordial and complimentary on the work of the Society. The Society has been quite thoroughly advertised. A "follow-up" system should now be instituted.

The reasons for declining to apply for membership are numerous, but may be grouped into the following classes:

1. One practitioner says that he "honestly cannot see any reason for this Society. Your University is doing exactly this work. . . . I see no inclination among my fellowstatesmen to back up the Society." The reply to the first state-

ment is simple. The moral to be drawn from the second statement is that if the engineering educators of one of our eastern states are not sufficiently interested in the promotion of engineering education to become members of this Society, we must not expect the citizen-practitioners to take the lead.

2. Inability to attend meetings on account of present location.

3. Financial inability. This is especially true of the younger instructors. It raises the question if annual dues of $2.00, for teachers of the rank of assistant, or instructor, and for those who have not yet reached the title of Assistant Professor, would not be advisable.

4. The temporary employment of so many of our younger men in the *trade* of teaching until they can get into the active practice of the profession in the line desired.

5. Competition due to the prevalence of the "joining habit," and which is fostered by the present mania for forming new societies.

6. Lack of interest in engineering and technical education. This is both surprising and appalling. We doubt if the writers appreciated how their words would look when in cold type. Have outside and professional interests been allowed to so usurp the first place in the life of the professional educator, that he should be willing to write that he is "more deeply interested in other subjects," or that he "does not feel the need of a Society" having for its sole purpose the promotion of engineering education?

Your secretary has held that we have no desire to add to our list of members the names of either "dead timber" or "silent partners." It is a fact that only from 10 to 25 per cent. of the membership of any society ever attends any one meeting. All we ask of a member is that he will attend the meetings as often as possible and whenever convenient, that he will prepare and present papers whenever the spirit moves him to give to the Society the benefit of his experience, observations, judgment and suggestions, that he will take part in the discussions either in writing or orally whenever he can

add to their value, and finally, that he will show his interest in engineering education by remaining a member of the Society. Even in the case of the presidents of institutions having prominent engineering colleges, it is not much to ask of them that they shall show their interest in engineering education, and the work of a large number of their faculty, by becoming and remaining members of this Society. They would be benefited by attending our meetings, and we might be benefited by the discussions they would present. It is to be assumed that the chief business of most engineering professors is the work of engineering education, and that membership in our Society should appeal to them and have as high a claim on their support as membership in the national society of their special branch of the profession.

The work of the office of the secretary can be best pointed out by the statement that four letter files have been filled this year. Card catalogs have been begun of the engineering teachers of each of the engineering and technical schools, and also of those engineering practitioners who are thought to be most favorably inclined to consider membership. This first list has been reclassified by the subjects taught. It is thought that lists of the teachers of civil engineering, drawing, chemistry, etc., in the engineering schools with their present titles may be of value to some of our members. The secretary is fully aware that unfortunately the lists are badly in error, being no more correct than the catalogs which were available last winter and from which the information was drawn. However, the card catalog and lists have been started, and it is only a question of competent labor to keep them fairly correct and up-to-date.

It has also been suggested that it might be well to send to the members in April or May a list of engineering positions vacant, or desired, for the next college year, or immediately in practice. An employment exchange might be of service to many, and especially to the younger members.

By such helps as these, membership in the Society can be made of still greater value.

Unless one has dug into the treasure mine of the Society's membership, one is not likely to appreciate the value of the precious metals and jewels hidden below the surface of a title. It may be necessary to use a transit to get the bearings, and to turn on the juice to electrify it into action, and then to see that all parts are efficiently lubricated. It may be even necessary to borrow the "jolly" of our ceramic engineering friends to keep things running smoothly; but the result will be a largely increased output of high grade ore. Notwithstanding the length of the program of this meeting, it is a real pleasure to state that the present secretary is able to turn over to his successor promises of quite a number of papers for the next meeting, and a still larger number of possibilities.

WM. T. MAGRUDER,
Secretary.

June 29, 1907.

The report of the Treasurer, Anson Marston, was read and referred by the President to an Auditing Committee consisting of Professors A. J. Wood, Joseph A. Thaler and George R. Chatburn.

TREASURER'S REPORT, 1906–7.

To the Society for the Promotion of Engineering Education:

The treasurer would respectfully report to the Society the condition of its finances as follows:

SUMMARY OF RECEIPTS.

Cash on hand July, 1906	$ 545.44
Current and future dues	1054.65
Back dues	210.00
Sale of reprints to authors	56.88
Sale of proceedings	71.50
	$ 1938.47

SUMMARY OF EXPENDITURES.

Proceedings, insurance and freight	$ 25.52
Expenses of Ithaca meeting	119.08
Secretary's expenditures	140.65
Treasurer's expenditures	41.85
Secretary's honorarium	100.00
Balance, July 1, 1907	1511.37
	$ 1938.47

At date of writing this report the bill for printing and distributing the Proceedings, which always constitutes more than one half of the total expenses of the Society, has not been rendered to the treasurer.

However, it seems certain that the real cash balance of the Society is materially increased over July 1, 1906, owing mainly to an increase of $134.75 in the amount of current and future dues, of $96.00 in the back dues collected during the year.

It may be of interest to note that the total amount of back dues still on the books of the treasurer is $258.00. There are in all, 49 delinquents, of whom 27 owe $3.00 each, 10, $6.00 each, 9, $9.00 each, and 3, $12.00 each.

Respectfully submitted,

A. Marston,
Treasurer.

June 29, 1907.

The applications of certain persons having been approved by the council, on motion they were duly elected members of the Society. (See page 22.)

No business coming before the general session, the first paper of the meeting was presented. It was entitled "The Relation of Philosophy to Science," and was read by the author, Mr. Bassett Jones, Jr., Consulting Engineer, New York City, and was discussed by Dean Kent and the author.

The next paper was on "Engineering Education before and after the War," by J. Burkitt Webb, Professor of Mathematics and Mechanics, Stevens Institute of Technology. It was followed by one entitled "Engineering Chemistry or Chemical Engineering," by Charles F. Mabery, Professor of Chemistry, Case School of Applied Science, Cleveland.

The next paper read described "An Educational Experiment," and was by William G. Raymond, Dean of the College of Applied Science, and Professor of Civil Engineering, State University of Iowa. It was followed by one on "Pedagogic Methods in Engineering Colleges," by William Kent, Dean of the College of Applied Science, Syracuse University. These papers were discussed by Professors C. M. Woodward, Williston, Higbee, F. C. Caldwell, Turneaure, Chatburn, W. Kent, Magruder, C. S. Howe, Webb, Emory, Boyd, White, Jacoby, Constant, Leete, Wiley, Henry T. Eddy, D. C. Jackson, A. N. Talbot, Raymond, Kent and Mabery.

A paper on "The Relative Efficiency of Instruction in Engineering Subjects" was then read by James M. White, Professor of Architectural Engineering and Dean of the Engineering College, University of Illinois. (For discussion see report of evening session.)

EVENING SESSION, 7:30 O'CLOCK.

The first business of the evening session was the discussion of Professor White's paper, in which the following gentlemen took part: Professors Wood, Williston, W. G. Raymond, A. N. Talbot and Webb.

In the absence of the authors, the paper on "The

New Electrical Engineering Building of the Worcester Polytechnic Institute," by Harold B. Smith, Professor of Electrical Engineering, and Arthur W. French, Professor of Civil Engineering, Worcester Polytechnic Institute, was read by title.

The next papers read were one on "The Organization and Conduct of an Electrical Engineering Laboratory," by John W. Schuster, Assistant Professor of Electrical Engineering, University of Wisconsin; and one on "Central Station Design," by Albert A. Radtke, Professor of Electrical Engineering, Armour Institute of Technology. These papers were discussed by Professors Radtke, Brackett, F. C. Caldwell, Wood, Dates and M. Brooks. Professors Schuster and Radtke closed the discussion.

A paper on "The Basic Principles in the Construction of a Textbook," by Stephen E. Slocum, Professor of Applied Mathematics, University of Cincinnati, in the absence of the author, was read by the secretary. It was discussed by Professors Franklin and Magruder.

The next paper was on "Methods of Studying Current Technical Literature," by Henry H. Norris, Professor of Electrical Engineering, Cornell University. In the absence of Prof. Norris, his paper was read by the Secretary. It was discussed by Professors White, Brackett and Chatburn.

The last paper of this session described "The Building and Equipment of the Rockefeller Physical Laboratory of the Case School of Applied Science." It was presented by Professor Dayton C. Miller, Professor of Physics, Case School of Applied Science.

The reading of the paper was followed by a series of demonstrations of the apparatus of the lecture room in which the meeting was held, after which the visiting members inspected the building and apparatus.

Tuesday, July 2, 1907.

MORNING SESSION, 9:30 O'CLOCK.

The applications of certain persons having been approved by the Council, on motion they were duly elected members of the Society. (See page 22.)

The first paper presented at this session was entitled "The Six-day System at the University of Minnesota," by Frank H. Constant, Professor of Structural Engineering, University of Minnesota. It was followed by one descriptive of "The Work of the Freshman and Sophomore Years of the Engineering Courses," by Fred A. Fish, Professor of Electrical Engineering, Iowa State College. These papers were discussed by Professors Kenyon, C. M. Woodward, Schuster, F. C. Caldwell, W. G. Raymond, Cooley, Williston, W. Kent, Turneaure, Magruder, Bass, C. Russ Richards, Brackett, Webb and D. C. Jackson. The discussion was closed by the authors.

A paper on "A Combined Cultural and Technical Engineering Course" was read by the author, George R. Chatburn, Professor of Applied Mechanics and Machine Design, University of Nebraska. It was followed by one entitled "Technical Education with a View to Training for Leadership," by Fred W. Atkinson, President of the Polytechnic Institute of

Brooklyn. In the absence of President Atkinson, the last-named paper was read by the Secretary. They were discussed by Professors Rowland, the Secretary, W. Kent, Goetze, C. S. Howe, F. C. Caldwell, C. M. Woodward, Haupt, Franklin, Constant, W. G. Raymond, D. C. Jackson, Cooley and Williston. The discussion was closed by Professor Chatburn.

AFTERNOON SESSION, 1:30 O'CLOCK.

The first paper of the afternoon session was entitled "The Functions of the Dean of a College of Engineering," by Frederick E. Turneaure, Dean of the College of Engineering, University of Wisconsin. This was followed by one descriptive of "The Duties and Work of the Dean in a College of Engineering," by James M. White, Professor of Architectural Engineering and Dean of the Engineering College, University of Illinois; and another entitled "Some Phases in the Organization of State Universities," by Louis E. Reber, Dean of the School of Engineering and Professor of Mechanical Engineering, Pennsylvania State College. In the absence of Professor Reber, his paper was read by Professor A. J. Wood.

In the absence of their authors, the papers by Henry B. Ward, Corresponding Secretary of the Society of the Sigma Xi, on "The Part of Sigma Xi in Scientific Education," the paper by Edward H. Williams, Jr., Founder of the Tau Beta Pi Association, on "The Place of the Intercollegiate Scientific Fraternity in an Engineering College," and the paper by R. C. Matthews, Secretary of the Tau Beta Pi

Association, on "The Tau Beta Pi Association," were read by title.

The next paper was entitled "A Course in Physics for Engineering Students," by William S. Franklin, Professor of Physics, Lehigh University. It was followed by one on "The Teaching of Elementary Mechanics," by William S. Franklin, Professor of Physics, and by Barry MacNutt, Assistant Professor of Physics, Lehigh University. They were read by Professor Franklin. The papers were discussed by Professors Merriman, Cooley, W. Kent, Williston, Maurer, Haupt, A. N. Talbot, Howe, Chatburn, Emory, F. C. Caldwell, Benjamin, Miller, C. R. Adams, Jr., C. M. Woodward and Brackett. Professor Franklin closed the discussion.

TUESDAY AFTERNOON, 4 O'CLOCK.

The members of the Society adjourned the afternoon session at four o'clock to attend a reception tendered to them and their ladies by the Ladies of the Faculty of the Case School of Applied Science. The reception was held in the library of the Physical Laboratory. It was a delightful occasion, charmingly informal and was enjoyed by all. The only disappointment was that so few of the visiting members were accompanied by their wives. The hearty and united hospitality of the ladies of the faculty of Case School is worthy of emulation. It is felt that to know a member in the sessions of the meeting may be to know something of his mental powers, but to know the whole man, one must also meet him socially.

EVENING SESSION, 7 O'CLOCK.

In the evening the Trustees and Faculty of the Case School, not to be outdone by the ladies, entertained the members of the Society at dinner at the University Club.

Both of the social functions tendered the visitors are worthy of commendation, as examples. President Howe acted as toastmaster. Post-prandial remarks were made by the Hon. J. M. Henderson, Esq., President of the Board of Trustees, and by Mr. Worcester R. Warner, member of the Board of Trustees of the Case School.

President Jackson delivered the presidential address, entitled "The Relation of the Engineering Schools to Polytechnic Industrial Education." It was discussed by Professors Henry T. Eddy, C. M. Woodward, Williston, Franklin, Goetze, White, Turneaure and Mr. Warner. President Jackson closed the discussion.

WEDNESDAY, JULY 3, 1907.

MORNING SESSION, 9:30 O'CLOCK.

The applications of certain persons having been approved by the Council, on motion they were duly elected members of the Society. (See page 22.)

The first paper read at this session was on "The Cooperative Course in Engineering at the University of Cincinnati." It was read by the author, Herman Schneider, Professor of Civil Engineering and Dean of the College of Engineering, University of Cincinnati. It was followed by one on the same subject by

Charles S. Gingrich, of the Cincinnati Milling Machine Company, representing the manufacturers of Cincinnati. The papers were discussed by Professors W. Kent, Emory, D. C. Jackson, Jacoby, Franklin, W. G. Raymond, Williston, J. D. Hoffman, Wessling, Magruder, Brackett, C. S. Howe and F. C. Caldwell. Dean Schneider answered their questions.

The Nominating Committee, consisting of Past-Presidents Eddy, Woodward and Crandall, and Councilors Caldwell, Ford and Williston, through its Chairman, Professor Eddy, presented the following nominations for the officers for the ensuing year:

For President: Charles S. Howe, President of the Case School of Applied Science, Cleveland, Ohio.

For Vice-Presidents: Clarence A. Waldo, Head Professor of Mathematics, Purdue University, Lafayette, Ind., and William G. Raymond, Dean of the College of Applied Science, State University of Iowa, Iowa City, Iowa.

For Secretary: Arthur L. Williston, Director of the Department of Science and Technology, Pratt Institute, Brooklyn, N. Y.

For Treasurer: William O. Wiley, Secretary of John Wiley & Sons, 43 East 19th St., New York, N. Y.

For Members of the Council whose terms expire in 1910: Fred W. Atkinson, President of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y.; Mortimer E. Cooley, Professor of Mechanical Engineering and Dean of the Department of Engineering, University of Michigan, Ann Arbor, Mich.; Wm. S. Franklin, Professor of Physics, Lehigh University, South Beth-

lehem, Pa.; William Kent, Dean of the College of Applied Science, Syracuse University, Syracuse, N. Y.; Walter B. Russell, Assistant Superintendent of Apprentices, New York Central Lines, Brooklyn, N. Y.; Charles F. Scott, Consulting Engineer, Westinghouse Electric and Manufacturing Company, Pittsburg, Pa.; Harold B. Smith, Professor of Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass.

On motion, the Secretary of the Society was instructed to cast the unanimous ballot of the members present for the list of officers as proposed by the Nominating Committee. He did so, and the Chairman declared them elected.

The committee appointed to audit the books of the Treasurer reported as follows:

REPORT OF AUDITING COMMITTEE.

Your committee, appointed to audit the accounts of the treasurer for the year 1906–7, respectfully report that they have examined the accounts and vouchers of the treasurer and have found them correct as reported.

ARTHUR J. WOOD,
GEO. R. CHATBURN,
J. A. THALER.

On motion, the report of the committee was accepted and the committee discharged.

On motion, the report of the Treasurer was accepted with an expression of the appreciation of the Society for his services.

The Chair announced that the Committee on the Revision of the Constitution would consist of the in-

coming Secretary, and Professors C. M. Woodward, Francis C. Caldwell, George F. Swain and Charles F. Scott.

The next number on the program was the report of the Committee on Industrial Education. It was read by Calvin M. Woodward, Chairman, Dean of the School of Engineering and Architecture, Washington University, and by Arthur L. Williston, Director, Department of Science and Technology, Pratt Institute.

On motion, the report was accepted and ordered to be printed in the Proceedings of the Society. On motion, the committee was continued for another year and requested to furnish a statistical report.

On motion, the Committee on Requirements for Graduation was discharged.

AFTERNOON SESSION, 1:30 O'CLOCK.

The first paper read was entitled "The Student Apprenticeship System from a Manufacturer's Standpoint," by Albert G. Wessling, Assistant Engineer, Allis-Chalmers Company. It was followed by one on "The Special Apprenticeship Course," by Charles E. Downton, Foreman of Apprentices, Westinghouse Electric and Manufacturing Company; and another entitled "The Engineering College and the Electrical Manufacturing Company," by Charles F. Scott, Consulting Engineer, Westinghouse Electric and Manufacturing Company. In the absence of Mr. Scott, his paper was read by the Secretary.

The three papers were discussed by Messrs. Bump

and Russell, Professors Magruder, W. Kent, Emory, Wood, Maurer, F. C. Caldwell, C. M. Woodward, Williston and D. C. Jackson. The discussion was closed by Messrs. Wessling and Downton.

In the absence of the authors, the paper by Mr. Arthur D. Dean, Special Supervisor, Department of Industrial Education, Young Men's Christian Associations of Massachusetts and Rhode Island, on "Education for Industrial Workers," and the paper by Mr. Hugo Diemer, Consulting Engineer, Goodman Manufacturing Company, on "Courses in Industrial Engineering," were read by title.

The President, Dugald C. Jackson, presented the following resolutions, the Secretary being in the Chair:

WHEREAS, It is desirable to make a comprehensive study of the objects and the utilities and the correct ideals of engineering education; therefore, be it

Resolved, That the Society for the Promotion of Engineering Education hereby invites the respective governing boards of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the American Chemical Society each to appoint two members to become delegates composing part of a Joint Committee on Engineering Education, which committee shall consist of the said two members appointed from each of the aforesaid societies, or the delegates of such societies as accept this invitation and appoint their respective delegates, and three

members appointed as delegates by the Society for the Promotion of Engineering Education; and in pursuance hereof, be it further

Resolved, That the Council of the Society for the Promotion of Engineering Education is hereby directed to appoint three members as delegates to the membership of the said Joint Committee on Engineering Education; and further

Resolved, That the duty of said Joint Committee on Engineering Education shall be to examine into all branches of engineering education, including engineering research, graduate professional courses, undergraduate engineering instruction, and the proper relations of engineering schools to the secondary industrial schools or foremen's schools, and to formulate a report or reports upon the appropriate scope of engineering education and the degree of cooperation and unity that may be advantageously arranged between the various engineering schools; and that the said joint committee be requested to make a report of progress to this Society within a year, and to make its final report to this Society within two years.

On motion, the resolutions were adopted and the Council authorized to take action.

The Committee on Resolutions made its report through its chairman, Dean Woodward. On motion, the report was adopted.

Report of Committee on Resolutions.

It is a pleasure to place on record our feeling of gratitude for the kind offices which have tended to make this meeting of our Society doubly successful. Our numbers in attendance

have never been so large; the atmosphere has never been so clear and bracing; and the pleasure of our meetings has never been so unbroken. We submit the following Resolution for the Society's adoption.

1. *Resolved,* that the hearty thanks of this Society are due and are hereby given to the Board of Trustees of the Case School of Applied Science for the use of this beautiful and convenient Rockefeller Laboratory of Physics, and above all for the most enjoyable banquet and evening at the University Club.

2. To the President and Faculty of the Case School of Applied Science, we give thanks for the thoughtful attention to all our wants while on the College Campus.

3. We are especially grateful to the Ladies of the Faculty for the delightful reception on Tuesday, and the charming automobile ride on Wednesday morning given to the wives and lady friends of our members. Such courtesies encourage the attendance of the ladies and enhance the attractions of our meetings.

Respectfully submitted,

C. M. Woodward,
A. H. Ford,
Arthur L. Williston.

An illustrated paper descriptive of "Some Classroom Experiments in Mechanics" was next presented by James E. Boyd, Professor of Mechanics, Ohio State University. It was followed by one by Edward R. Maurer, Professor of Mechanics, University of Wisconsin, on "Some Questions Relating to the Course in Mechanics." The secretary then read a paper by Walter Rautenstrauch, Adjunct Professor of Mechanical Engineering, Columbia University, on "The Teaching of Applied Mechanics to Engineering Students." These papers were discussed by Professors W. Kent, C. M. Woodward, and Benjamin.

A paper on "The Engineering Experiment Station at Iowa State College" was read by George W. Bissell, Ex-Professor of Mechanical Engineering, Iowa State College. In the absence of the author, the secretary read a paper by L. P. Breckenridge, Professor of Mechanical Engineering and Director of the Engineering Experiment Station of the University of Illinois, on "The Engineering Experiment Station of the University of Illinois." These papers were discussed by Professors Wood, Turneaure, Franklin, W. G. Raymond, and Bissell.

On motion of Professor Franklin, the recommendation contained in Professor Breckenridge's paper was referred to the Joint Committee on Engineering Education for recommendation.

EVENING SESSION, 8:00 O'CLOCK.

The first paper of the evening was by Charles H. Benjamin, Professor of Mechanical Engineering, Case School of Applied Science, and was entitled "Looseleaf Notes for Laboratory Use." It was discussed by Professors J. D. Hoffman, C. R. Jones, and Brackett.

A course in "The Teaching of Elementary Machine Design" was then described by James D. Hoffman, Associate Professor of Engineering Design, Purdue University, and discussed by Professors Benjamin, Bissell, Wood, and Magruder, with closure by the author.

The next paper presented was entitled "Some Examination Data," by Rosser D. Bohannan, Professor of Mathematics, Ohio State University. In the absence of Professor Bohannan, his paper was read by the Secretary.

In the absence of Professor Henry H. Norris, Professor of Electrical Engineering, Cornell University, the Secretary read his paper, entitled "The Technical and Pedagogic Values of Examinations." The discussion on these two papers was conducted by Professors Jacoby, Benjamin, Brackett, Magruder, C. S. Howe, W. Kent, Higbee and D. C. Jackson.

In the absence of Otis E. Randall, Professor of Mechanics and Mechanical Drawing, Brown University, the Secretary read his paper on "Descriptive Geometry—Its Importance in the Engineering Curriculum, and the Methods of Teaching It." The discussion on this paper was by Professors Fuller, W. Kent, Williston, Benjamin, C. S. Howe, Higbee, J. D. Hoffman, Magruder and Jacoby.

In the absence of William H. Schuerman, Professor of Civil Engineering, and Dean of the Engineering Department, Vanderbilt University, the Secretary read his paper, entitled "The Honor System of Examinations." It was discussed by Professors Benjamin, W. Kent, C. R. Jones, Wood, D. C. Jackson, C. S. Howe, Williston and Magruder.

In the absence of their authors, the following papers were presented and read by title:

(*a*) "A Calculation Blunder Common to many Trigonometries used in Engineering Colleges."

(*b*) "A Neglected Opportunity to Teach Consistent Measurement in Trigonometry," by Rosser D. Bohannan, Professor of Mathematics, Ohio State University.

"Athletics for Engineering Students," by Charles L. Thornburg, Professor of Mathematics and Astronomy, Lehigh University.

"What Should be Included in a Course in Engineering Jurisprudence," by Arthur H. Blanchard, Associate Professor of Civil Engineering, Brown University.

On motion, the meeting adjourned *sine die* at 11:30 P. M.

The record shows that thirty-nine papers were presented and read, and ten papers were read by title in the absence of their authors, making a total of forty-nine papers presented at the meeting.

The following members were present and registered at the meeting: C. A. Adams, Jr., F. H. Bass, C. H. Benjamin, G. W. Bissell, J. E. Boyd, B. B. Brackett, M. Brooks, A. T. Bruegel, F. C. Caldwell, G. R. Chatburn, C. B. Connelley, F. H. Constant, M. E. Cooley, C. L. Crandall, H. B. Dates, C. S. Denison, C. R. Dooley, R. G. Dukes, Henry T. Eddy, F. L. Emory, F. H. Eno, E. F. Fermier, F. A. Fish, T. M. Focke, A. H. Ford, W. S. Franklin, H. A. Gehring, F. A. Goetze, L. M. Haupt, F. G. Higbee, J. D. Hoffman, C. S. Howe, D. C. Jackson, H. S. Jacoby, B. Jones, Jr., C. R. Jones, E. B. Kay, W. Kent, C. P. Linville, C. F. Mabery, A. B. MacDaniel, J. E. Magnusson, W. T. Magruder, A. Marston, E. R. Maurer, D. C. Miller, F. H. Neff, E. L. Ohle, A. A. Radtke, W. G. Raymond, C. E. Reid, C. Russ Richards, W. B. Russell, A. R. Sawyer, J. W. Shuster, H. H. Stoek, A. N. Talbot, J. A. Thaler, F. E. Turneaure, S. M. Turrill, J. B. Webb, A. G. Wessling, J. M. White, W. O. Wiley, S. N. Williams, A. L. Williston, D. T. Wilson, A. J. Wood, C. M. Woodward (69).

The following guests were present and registered:

H. S. Carhart, A. N. Clark, T. H. Carter, C. S. Gingrich, A. M. Kenyon, J. H. Leete (6).

Total registration, 75.

Messrs. W. E. Downton, W. R. Warner and a number of the citizens of Cleveland also were present at one or more of the different sessions.

The following persons were elected to membership in the Society: John R. Allen, William A. Anthony, William S. Ayars, Earle J. Babcock, Frederick W. Ballard, Alburto Bement, George H. Benzenberg, Philander Betts, Frederick L. Bishop, Adolph Black, Rosser D. Bohannan, James E. Boyd, Milan R. Bump, Elwyn F. Chandler, Octave Chanute, Harry E. Clifford, Harry T. Clifton, Clifford B. Connelley, Arthur D. Dean, Channing R. Dooley, Richard G. Dukes, Louis E. Endsley, William D. Ennis, Frank H. Eno, Frederick H. Evans, Howard P. Fairfield, Theodore M. Focke, G. Harwood Frost, Franklin DeR. Furman, Harry O. Garman, George I. Gavett, Herbert A. Gehring, William B. Gregory, Frederick A. Halsey, Eugene E. Haskell, Lewis M. Haupt, William S. Hazleton, William W. Henley, Angus S. Hibbard, Arthur H. Hoffman, James D. Hoffman, John W. Hughes, Alexander L. Jenkins, John W. Johnson, Horace Judd, Charles Kirchoff, Carl D. Knight, William A. Knight, Charles T. Knipp, Frederick L. Kortright, Edward J. Kunze, Byron J. Lambert, Charles C. Leeds, Nathaniel W. Lord, William C. McNown, Charles F. Mabery, Allen B. MacDaniel, C. Edward Magnusson, Louis A. Martin, Jr., Joseph F. Merrill, Dayton C. Miller, David A. Molitor, Lewis E. Moore, Clyde T. Morris, Charles E. Morrison,

George H. Morse, Alexander W. Moseley, William E. Mott, Ralph E. Myers, Paul N. Nunn, Tinius Olsen, Frederick A. Osborn, Lawrence G. Parker, Andrew H. Patterson, Joseph O. Phelon, Hylon T. Plumb, Albert A. Radtke, Walter Rautenstrauch, Clarence E. Reid, Albert S. Richey, Henry F. Rugan, Herbert C. Sadler, Arthur R. Sawyer, Edward C. Schmidt, Howard B. Shaw, Christopher E. Sherman, William A. Shoudy, John W. Shuster, George Smart, Henry L. Smyth, J. Verne Stanford, Harry H. Stoek, Frank Strong, William O. Thompson, John C. Thorpe, L. G. Van Ness, John C. Wait, Kenneth B. Ward, Roy I. Webber, Arthur C. Willard, Albert G. Wessling, Gardner S. Williams, Joseph D. Williams, Delonza T. Wilson, James R. Withrow, Gilbert A. Young, Anthony Zeleny (107).

Respectfully submitted,

WM. T. MAGRUDER,

Secretary.

ADDRESS OF WELCOME.

BY CHARLES S. HOWE,
President of Case School of Applied Science.

I see that I am on the program for an address of welcome; that is a mistake—it should have been a word of welcome.

In behalf of the authorities of Case School of Applied Science, it gives me great pleasure to welcome you to the city of Cleveland and to this institution. We think the city of Cleveland is a very good place to hold conventions. Its climate is usually pleasant. It never rains when we have conventions, and on this account it is pleasant for people to come here. Cleveland is a city of homes. We have very few great blocks such as you find in eastern cities, but almost every house stands back from the street, surrounded by shrubbery and shade trees. This is called the Forest City on account of the beautiful trees which line the streets and are found on the lawns in front of our residences. Cleveland is also a manufacturing city and the manufacturers will welcome you to their establishments and give you every opportunity to see what is going on.

So, although I have no official authority to do so, I know I may, in behalf of our citizens, welcome you to the city of Cleveland. I surely can welcome you to the Case School of Applied Science. All that we have, recitation halls, libraries, laboratories, is at your command and I trust you will make yourselves at home. Everything we can do to make this meeting pleasant and profitable for you will be done, and so again I bid you welcome.

THE RELATION OF PHILOSOPHY TO SCIENCE.

By BASSETT JONES, Jr.,
Consulting Engineer.

In a paper read before this society at the fourteenth annual meeting in Ithaca, I took for my text, a quotation from Rousseau's "Emile"—"The art of living is the trade we are to teach."—I therein attempted to show that no system of education, technical or otherwise, can hope to claim success for itself unless it pays due attention to the subject of right living—unless it can give evidence that the life purpose instilled into the mind of the scholar is adapted to his individual needs, and that his mind is so trained that he grasps the meaning of the world with sufficient clearness to enable him to set before himself a model worthy of imitation.

The discussion of this thesis led us directly into the field of philosophy, and we found that the very act of attempting to appreciate the meaning of the world, the individual, and their relations was philosophy's problem. "The Benefit of Philosophy to the Engineering Student"—indeed, the benefit of philosophy to every thinking individual, is that, by a study of just these philosophical problems, he is enabled to so gauge the purpose and meaning of the world that he can distinguish his own place within it and so work out his own salvation, and self-development.

In a philosophical mood, Ibsen once wrote to a friend—"So to conduct one's life as to realize one's

self—this seems to me to be the highest attainment possible to a human being. It is the task of one and all of us, and most of us bungle it.'' I think you must all agree that the source of this bungling lies not so much in our failure to try at the best life attainable as in our failure to know just what form the best life should take. Too few of us have been trained to philosophise about life. We do not know how to analyse our experience and to pick up the threads of purpose which experience brings to us so as to weave them together in any practical form. And so, through ignorance, we are compelled to leave to the uncertain Fates the duty that by right belongs to each one of us. Most of the stuff of which experience is made is never translated into consciousness and slips by unheeded until it is too late to realize the meaning of the opportunities so presented.

The only possible comparison of the worth of individual life, we argued, is whether the sum is fuller consciousness or not. The material of our naïve experience must become conscious before it can furnish a basis for action. The problem is then, how are we to select from our translated experience the criteria for development. This is a matter for judgment and judging is thus a selecting activity. But the organic functioning of judgments must be adequately under control, and this control is itself a matter for conscious choice whose intellectual parallel we find in the judgments of formal logic. The logic of judgments is then of vast importance in the training of the mind, for judgment must never be reckless

in its choice but governed by the end in view. To judge adequately therefore, we must first determine the teleological aspect of the conscious process. What I ought to do with myself is the fundamental question, but before this question can be answered I must know what I myself am—what this organic process I term "myself" means. And this again, is a question for philosophy to decide.

Now a process, whether organic or inorganic in its nature, is never a matter of the immediate moment. It is equally a thing of the past and of the future. And its full meaning—its purpose—is found only in the unity of a conscious span that holds equally present all the steps in its development.

This may perhaps be made somewhat clearer by a little study of the time concept. It is a common saying that all things exist in time. It would be truer to say that all things change in time, for nothing exists that does not change, and without the category of change nothing could exist. Our ability to grasp the nature of things depends upon the ratio of the rate of change taking place in them to the rate of change of our conscious activities, and we only grasp so much of their nature as can be encompassed within the limits of our conscious span.

Consider these words as I speak them. One single word carries little if any of my meaning to you. But as I continue you catch more and more of my idea until, at the end of the sentence you have presented to your mind a sequence of words the meaning of which you grasp all at once. You do not get my meaning merely by the last word spoken, but by

holding together in your mind the entire sentence, first equally with the last, not only in its aspect as a succession in time but also all at once. And it is this "all-at-once-ness"—this unity of many things in a single conscious span—that enables you to identify the meaning of the spoken succession of words. And further, I may talk so fast that it would be utterly impossible for you to get my meaning, or again the words may come so infrequently that they may appear absolutely without connection and so without purpose. As with the sentence, so with the paragraph, and so with the entire article. You then have in your mind a sequence of ideas all of which you hold together within the span of one conscious effort of attention.

A similar example may be given in the musical phrase. In one of his letters Mozart tells a friend that, to him, the purest delight in music is the moment when he holds within his mind and in one conscious period the entire piece he is composing, and this before he has written a single note! How hopeless to us then seems the task of comprehending the real meaning embodied in so gigantic a composition as one of the later Beethoven sonatas!

And then turn from this to the work of encompassing the meaning of even a mere fragment of Nature's activities. Surely the discriminating work of science and the appreciations of philosophy seem beyond the scope of human understanding.

Yet whatever meaning we are to ascribe either to ourselves or things is subject to just these thought processes that we have been illustrating. For our

knowledge of the world or of things only appears as we succeed in arranging our experiences in linked series of states having a definite character and possessing a certain teleological aspect. But, as our examples illustrate, the teleology of a process is never expressed merely in the last term. It is given only in the process itself—namely, in just this series of states which we are selecting out of the felt background of experience, and each term, the first, as well as the last is equally important in giving meaning to the entire series. It is never the momentary state of the thing as it stands there, having reached its maximum development in any one period, that makes the object what it is in reality. You do not grasp the full purport of this sentence away from its context. Its meaning is bound inseparably with what is past and with what is yet to come. So with the thing—what it is is somehow a part of what it was and what it is to be.

The organic parallels of this conscious activity are the phenomena of *attention* and *association*. "It is accomplished in the organism by an arrangement (of the brain structure) whereby a group of processes corresponding to what we call in consciousness copies for imitation, some of them external as things (as the spoken words immediately present to the auditory sense), some internal as memories, conspire, so to speak, to 'ring up' one another. When an external stimulus starts one of them, that starts up others already in the (brain) centers and all the reactions which wait upon these several processes tend to

realize themselves as a single ideal motive or meaning."*

Now whatever a thing may really be, we know it only in terms of its qualities. All our classification and arrangement of things for either scientific or practical purposes is in terms of qualities—namely, those qualities that are more or less persistent or recurrent through a number of states of the object, and, of course, equally constant through the corresponding states of our consciousness. It is those qualities of this sequence of states that we can agree upon as not only common to these several states but also common to our several series of conscious states that serve to give the object its place in the world and define this sequence of states as "of" the object.

Those qualities that are not persistent are either ignored or lose themselves in the general background of nature as not of sufficient importance for our purpose of describing how things behave. But our purpose in thus describing things and discriminating their recurrent qualities is determined by the use we wish to make of them. That is, *as experience comes to us in the bulk we attentively select so much of it as we require to make our lives more definite.* We look continually for those things that will best serve to embody our purpose.

Each one of us takes his own view-point and qualifies the object according to what he hopes to do to it. The artist will lay stress on certain harmonies of color or form. He will see in the object certain

* "Mental Development in the Child and the Race," Baldwin, p. 266. The parentheses are my own.

qualities that perhaps do not appear to the scientist, while the scientist in his turn sees certain inner relations of part to part; certain inner activities of growth or development and external relations to the environment. The artisan sees in the object qualities that determine its particular applicability to his own particular industry.

Thus every particular thing holds within itself an indefinite number of qualities. And which of these qualities shall form our knowledge of the nature of the object, is determined as much by our own life purposes and actions toward the object as they are determined by the action of the object upon ourselves.

Our discussion however, is to confine itself to the scientific attitude. The aim of science is thus never the mere discrimination of facts. It is the conscious classification of these facts as knowledge and the discernment of the relation of these classifications to ourselves that is the *raison d' etre* of scientific inquiry. But in order to classify we must have a purpose in view, and this purpose, as we now see, is to gain a greater scope for self-development. It takes its general form in an attempted unification of all nature in a conception that will include both the meaning of the world and of the individual. It attempts to draw together all the various threads of ordered experience in a single conscious moment precisely as you grasp at once the several threads of an argument in a conception of its meaning. This conception serves to guide the process of self-development. It is an essential factor in our being for it at least in some way shows us where we stand and acts as a foundation for further growth.

In a paper read before this society at its last annual meeting it was stated that men are the principal tools an engineer has to use. I think it must now be evident that not men, but his own mind is the principal tool that any individual must learn to handle—be that individual an engineer or not. To properly use his mind, a man must know what his mind is and how it works, and this is not a matter of engineering. It is the subject of philosophy and its more immediate sciences, formal, and functional logic. The man who lacks a training in the mental sciences must somehow make up this lack during his career by a piecing together of the trains of experience. How to look for these he does not know, and his habits of thought must of necessity be more or less haphazard in their development, except in so far as heredity and phylogeny are predominant in a logical form. The lack of such beneficial heredity can only be counteracted by a proper training during the plastic years of ontogenetic development.

I do not see that there is any necessity of introducing further argument in favor of the introduction into the curriculum of what your secretary's circular note so aptly characterizes as "The Missing Courses in Logic and Philosophy."

The direct relations of philosophy and science must now be palpably evident.

Science tells us *that* experience has such and such a form. Philosophy tells us *what* this experience means. Neither has any claim to the greater worth. Each is the other's complement. Both were born of the same desire and under the stimulus of the

unsolved world knot. What does it all mean? That is the question that both must share in answering.

The work of science, as I have earlier said, is the translating into consciousness of naïve experience, and this translation must necessarily be subject to the very form of consciousness itself—namely, of the type of the well-ordered succession discussed in our earlier examples.

Science consists in the organization of experience in such a way that we may find therein a guide to our behavior toward nature. A practical philosophy of life is then required to show us how we ought to conduct ourselves so that our behavior and the behavior of nature as defined by natural law shall not conflict. Every action implies a reaction and therefore at least two active beings, each of which must be conceived as doing something to the other. Nature and finite mind are therefore included in the one reaction which exemplifies the failure of the finite individual to make his activities accord with those of nature. Cosmology or the philosophy of nature is therefore founded on a social contrast which is involved in the relations of our life and the life of nature. I say *our* life advisably. For "all views of man as a total creature must recognize him not as a single soul shut up in a single body to act or to abstain from acting upon others similarly shut up in similar bodies; but as a soul, partly in his own body, partly in the body of others, to all intents and purposes, so intimate is this social band."*

But nature is known to us only through our senses and these merely give us qualities—a system of signs

* *Op. cit.*, Baldwin, p. 145.

—which we agree to interpret as the signs of the existence of a material world. But, "What our senses thus make known to us means little enough until the data of sense have been organized into a scheme of conduct."† Thus science builds for us a world and this ordered world of science expresses our purpose to find a scheme of behavior—a scheme which ultimately must be our own.

The conceptions of science are, thus, "themselves mental phenomena, for the understanding of which we must resort to a study of the constitution of reason itself."‡ In fact all knowledge is based on reason. There is no knowledge of the unreasonable. What may now appear unreasonable is itself reasonable, provided we go far enough. Unreason is itself merely the ignorance of reason. Knowledge is, *per se,* the knowledge of truth—the two terms are synonymous. The bare sensation of reality is not knowledge. Knowledge is the reflective attitude of a mind well-ordered in its processes. All well-ordered processes are reflectively described in laws of sequence. Thought, or the processes of mind, so described form the laws of logic. The laws of logic applied to the ordered mind content is science. The study of the relations of mind and its content is philosophy.

The criteria by which the truth of scientific conceptions can be judged therefore cannot be furnished by science itself, but rather by philosophy. For we cannot assert that the so-called facts of the "outer world" —the facts of sense—are any more real than the facts

† "The World and the Individual," Royce, p. 158, Vol. II.
‡ "Philosophy of Knowledge," Ladd, p. 4.

of mind, namely, the inner facts of cognition—thoughts. Are those things alone real that we encounter through our sense, then our thoughts are not real, and so our outer facts may not be real, for our thoughts, whereby we know these outer facts to be real, are themselves not real. Truth cannot be one-sided. It must take equal account of the fact and the knowledge of the fact.

Philosophy alone can pretend to define the ultimate relations of thought to reality or to define the nature of reality, for "the question as to the truth of our knowledge and the question as to the ultimate nature of what we know are but the two sides of the same inquiry" and themselves constitute the subject matter of philosophy.

You see therefore that on every side science escapes from its dilemma only to find itself merged in philosophy. But this does not mean that philosophy is in any sense higher in its scope than is science. It merely indicates how very close is their relationship, and that as soon as it attempts to draw conclusions science becomes philosophy.

The subject matter of philosophy is, as we now see, in no wise different from the subject matter of science. Its object is the discovery of the nature of the real world in which we live and have our being. The only way in which it differs from the special sciences, is that it is the science of the whole. It is with the ultimate synthesis that the philosopher concerns himself and the importance of this synthesis to the scientist we have now somewhat roughly indicated. The relation of philosophy and science is a reciprocal rela-

tion. Science gives philosophy its subject and philosophy criticises the material thus furnished in the light of the relations of fact and knowledge. The work of the scientific specialist is of little value until it is coordinated with all other branches of knowledge, and compared with the entire mind content so assembled. Philosophy is to the several sciences what the coordinating activity of the mind is to the separate words of the sentence, or the individual notes of the musical phrase.

Plato defined the philosopher as he who insists on seeing things together, and so the scientist himself must be more or less of a philosopher—otherwise, indeed, he would be no scientist. But too few scientists are either trained, or aroused to the importance of the implications of their knowledge in furthering their own work.

Historically, philosophy and science were originally one. To thc time of Aristotle, and including Plato, science was fused with philosophy in a single synthesis taking the form of a politico-religious system. It was the methodic thinking of Aristotle that led him to separate the several view-points so confounded, but the greatest importance was always attributed by him to what he styled "the first philosophy" or the science of first principles—an enquiry into the ultimate nature of reality which has since become our science of "metaphysics."

It was not, however, until much later—in the Alexandrian period—that the special sciences arose, and, as the vast mass of modern knowledge accumulated, men became, by special interest, opportunity, or train-

ing, more and more exclusively devoted to specialties and the breach between the several sciences and between the sciences and philosophy became more clearly defined. The growing mass of data and the complexity of experience combined with the sluggishness and comparatively narrow limits of the human understanding drove men into more and more confined lines of investigation. The divorce between the physical and mental sciences was apparently complete.

But this condition of affairs was a positive danger that gave rise to unpractical dreaming on one side and rank materialism on the other. And it was not until the conceptions of science narrowed themselves down to the postulate of a single universal and immutable energy that men realized that the path hewn out by science must eventually lead nowhere unless some account was taken of just these considerations that I have tried to lay before you to-day.

I am sorry that it has seemed necessary to give so much of my time to a discussion of the relation of philosophy to science rather than the purely educational matters, but the question usually is, what practical bearing on engineering can philosophy possibly have. And that is the question I hope to answer. A philosophy that is not practical is not good philosophy. Philosophy must have concrete results. *It must show that it does bear a direct influence for the betterment of everyday life.* As James has said, truth is a matter of the realization of ends through experience and so both thought and experience must serve to check one another.

It is with ideals and purposes, as such, that philos-

ophy is particularly fitted to deal, and these it does not make, any more than science makes nature. They are present in every age as a part of the general phenomena of life, but require to be organized and stated in a reasonable form and subjected to a critical analysis in the light of the relations of thinking beings to their environment. In the bare they lack appreciation and are not suited to the ordinary mind—"the man in the street"—the everyday practical individual. This difficulty it is the province of philosophy to correct.

The average person does not philosophize—he goes about his business of living with little or no critical thought as to whether his ideals are higher or more deeply ethical than those of his neighbor. Yet whatever ideals he has have been formulated for him by suggestion chiefly from his teachers but also from his fellows, and are usually so submerged in unconsciousness habit that he fulfills or attempts to fulfill them with very little appreciation of their origin.

The point I wish to accent is this—that the ideals that the practical man—engineer and all, alike—is endeavoring to embody, are ideals that he either formulates for himself, in which case he is a philosopher, or else, and with by far greater majority, he receives these ideals second-handed by means of a selected and organized artificial experience, which is systematic education.

Those of you who are teachers, are perhaps, of all people in the world, the most ladened with responsibility, for the whole future development of both the individual and the race depends upon the results of

your labors in giving form to the growing mind. See to it, therefore, that your duties are not neglected. Let not your interest in science blind you to the fact that it is not nature but mind that forms the fundamental subject matter of your profession.

In this sense philosophy is the most practical science in the realms of knowledge. It is the great organizer, and whether we like it or not we must admit that it has given us all that we count most worthy in life.

Engineering is, of course, no more or less than applied science, and therefore, must be subject to the same influences that have helped to direct scientific inquiry. I think it must now be clear that *philosophy is the yeast that aids us to properly assimilate and digest the data of science, and make it available for the practical development of the race.* The use of our coordinated experience with nature is the duty of the engineer. His is the work of fulfilling the purposes and practical ideals which philosophy develops. But he must be assured that these purposes and ideals are reasonable, logical, and, in the broadest sense of the word, ethical.

I do not mean to say that the engineer has a monopoly of the practical realization of ends. This would open the question as to what is most useful in life, and it is a subject quite outside of the scope of this paper. I think the fact is that we must frankly admit the great practical use of all fields of work that result in race betterment. They are all parts of one general scheme of development and none can be considered in its true light apart from the others.

The rise of engineering has been so rapid and so

phenomenal that perhaps undue accent has been laid upon its importance, particularly in this country where our applied æsthetic sciences are in so chaotic a state. But we must remember that nations live and die with their arts, and the present widespread interest in æsthetics that seems to have taken root in this country, is, I believe, one of the most hopeful signs of a great and lasting future. Our ideals and our purposes are naturally so different from those of the older world that their expression must take a decidedly different form. And considering our practically untamed natural environment, it is not at all extraordinary that the great efforts called for in our struggle with nature should have resulted in a mastery of practical engineering problems that has quite surpassed anything that has appeared in any other modern people. There is also no need for surprise at the fact, that, having once directed our thoughts to the problems of life, our wits, already sharpened by contact with nature, should have brought to these questions new ideas and new view-points that have turned the eyes of the world in our direction. The problems of education have been attacked, and methods have been proposed and adopted that have completely revolutionized the art of pedagogy. And this has been due, in great part, to the psychological classics of James, Baldwin and Morgan.

The problems of the future are not, however, the problems of to-day. And this is nowhere truer than it is in engineering. The men who are now leaving our educational institutions are the men who are to meet and master these problems, and they must be ade-

quately trained for their duties. Narrowness of view is an ethical crime. And engineering as a profession has certain relations to the rest of life that we should not neglect. Utility and economy are very well in their way but the problems of applied science are fast becoming much more than can be met by a solution, measured only in dollars and cents. The ultimate question is, what will best fulfill the needs of the race?

Discussion.

Dean Kent: On the general ground that an educated man should be interested in whatever interests humanity at large, an engineer may be pardoned if he devotes a portion of his time to reading a little philosophy such as he finds in the present paper. Humanity at large is now interested in Russia, in China, in the North Pole, in the Hague Conference, in the cure of consumption and of graft, in bacteria and protoplasm, in radium and electrons, in literature and the drama, in politics, in automobiles, in golf, in sociology, and in women's clubs. The intelligent engineer, to keep abreast of the times and to hold his own in conversation or even to be able to read with satisfaction in an ordinary modern magazine or newspaper must devote at least a small portion of his time to nearly all of these subjects. A hundred years ago he would not have needed to know anything about any one of them and therefore he might have devoted his leisure time to such subjects as conversation on the beauties of the Latin sonnet recently written by his friend in Oxford or to so and so's paper on the Greek aorist, or he might have reveled in study of Kant's

"Critique of Pure Reason," but the modern man has little time for any of such recreations. He must confine himself to the list of things I have given above with other modern fads, and if he meddles with philosophy at all, it must be in very minute doses. In fact for the last fifty years philosophy has gone out of fashion and it may be worth while considering whether the fact that it did go out of fashion is not one of the great causes of the scientific and intellectual advance of the race in the past fifty years. Nevertheless, every once in a while we see in some magazine or paper such names as Kant, Hegel, Schleiermacher, Schopenhauer, Hamilton and Lewes, and he is an ignorant man to whom these names do not bring some mental conceptions. The engineer who wishes to be educated should at least do so much as to read the article "Philosophy" in one or two good encyclopædias, but an engineer's life is too short for him to spend much time on the subject, unless he intends to adopt it as a hobby, just as some engineers take golf, others automobiling, and others novel reading. It is well that some people are so constituted that they can devote a large portion of their lives to a hobby; it is well for the information of the world at large that one man can spend years in collecting and studying musical instruments used in ancient times in the South Sea Islands, that another can study the languages of the extinct Indian tribes, that another can hunt for the north pole, another make explorations in Babylonia, another investigate the colors of butterfly wings, and another devote himself to the study of philosophy, which, as Kant says in one of

his definitions, is "a mere idea of a possible science which exists nowhere in the concrete but which we try to approach on different paths."

I occasionally read a little philosophy as a recreation, and so I have read Mr. Jones's paper. I have tried hard to find the meaning of it and to follow his argument to the effect that philosophy is of benefit to the engineering student, but I must confess that I am not quite clear as to what he means in many of his paragraphs and I fail to see that he has proved at all that philosophy ought to be studied by an engineer to any more serious extent than he should study any one of the long catalogue of things that I have named above. Any man who makes a hobby of one subject is apt to appreciate its value to far greater extent than his neighbors, and it is all right of course for him to preach about his hobby and try to get his neighbors to believe in it, but he must not be disappointed if they are so much taken up with their own hobbies as to have no time for any of his.

To criticize Mr. Jones's paper throughout would involve the writing of a longer article than the paper itself and I do not believe that our Proceedings would be benefited by any such article. I will only say that I not only differ with him as regards the benefit of philosophy to an engineering student, but also think a great many of his dogmatic statements are entirely wrong. For instance, his statement, "Our ability to grasp the nature of things depends upon the ratio of the rate of change taking place in them to the rate of change of our conscious activities." Let us consider the diamond. Does our ability to grasp as much as

the sciences of chemistry, crystallography, optics and mechanics have revealed to us concerning the diamond depend upon the ratio of the rate of change taking place in the diamond to the rate of change of our conscious activities? Again, "The only possible comparison of the worth of individual life is whether the sum is fuller consciousness or not." The sentence is rhetorically defective in that it does not show whether the worth of an individual life to one's self is meant or the worth to humanity. If the sentence means that the life which has the fuller consciousness is the more valuable then I must take exception to it. Suppose the concept should be toothache or corns! In that case, the fuller consciousness is not to be desired.

Mr. Bassett Jones, Jr.: My paper was given its full mete of criticism before it aroused Mr. Kent's merriment. It was submitted both to those whose judgment in matters of philosophy would, I believe, be generally recognized as adequate, and also to my school-boy brother in order to discover whether the argument was expressed in a form that would be ordinarily clear. I do not lay claim to any special ability in the matter of clear-written expression, but I did believe that I had so addressed my paper that its meaning and purpose could be grasped by people of ordinary intelligence. That my argument has not seemed clear, to Mr. Kent at least, is to me a source of keen disappointment!

Mr. Kent enunciates a variegated list of subjects, which he truly says should command the interest of every educated man. But the interest which each of these subjects will have for any individual will be

tempered largely, I take it, by the individual's own ideals and his general attitude to life—in other words, by his philosophy. What place the individual will give to politics, biology, ionization of matter, literature, sociology, or what-not, and what bearings he will conceive that any or all of these subjects have upon his own life will, of course, depend on what theory of reality he holds, and on what relations he considers that reality bears to himself. His opinions of the nature of the cosmos of which he forms a part may not be definitely articulated in his mind, but he nevertheless guides his life, and therefore indirectly helps to guide the life of others by these opinions.

But with the rise of society comes the necessity of unity in belief and action—and by society I mean that "socius," or relation of alter and ego, that is moulded, not by mere sympathy and intellectuality as such, but by the highest ethical influence, namely the category of the "ought."

If then we are to work together for the common good we must set before ourselves an ideal end that will at the same time be one for all good citizens and many for the separate individuals. The ideal must be such that all can strive for it alike, and yet the paths by which we, severally, can reach for it may be diverse. You and I, each one of us, must make our lives such that while we each pursue our separate specialties, we are yet working together to better ourselves as a collective whole. To do this we must, so to speak, pool our interests, beliefs and actions in order that we may achieve that common destiny which the psychologist, sociologist and philosopher alike

point out as the object indicated by the "set" of organic development.

Now since life is moulded by beliefs and ideals, and since the descriptive science, for lack of a better expression, of beliefs and ideals is philosophy, it seems reasonable that if society as a whole is to fulfill its manifest destiny, then each one of its members, in a general way at least, must hold a philosophy that will not clash with the philosophy of his neighbor. And to achieve this result the youth, the unfledged member of society, must have his ideals suitably moulded. It is not so much the question of the benefit of philosophy to the individual as it is the necessity that every member of society be trained to so order his life that there will be as little friction as possible between his life and the larger life of the socius of which he forms a part.

At one time I thought that this training of students to common ideals might be accomplished by teaching them technical philosophy. I wish now to modify that statement in so far as to say that whether technical philosophy is included in the curriculum or not, the student must be given the philosophic attitude of mind. He must become a man of *social ideals,* and I can not see that this requirement need conflict with the requirement that he become also a man of affairs.

I have no time or space to further develop my argument. I should like to refer Mr. Kent to the following forcible statements of the same principle in education, "The Danger of Over-specialization," by Dr. L. H. Baekeland, in *Science* of May 31, 1907, and "The Human Side of the Engineering Profession,"

by Professor V. Karepetoff, a paper read before the New York Electrical Society in 1907.

Technical philosophy may, and fortunately for society does, become a hobby with men of a certain cast of intellect. It is also fortunate that certain other men make a hobby of mechanics. The former run the danger of becoming purely idealistic, the latter too often become essentially materialistic, and each group, failing to see that both are wrong, will be prone to laugh and sneer. There is, however, a neutral ground where each may learn the lesson of moderation and learn it they must, sooner or later.

I think we may find two examples of this failure to see the other side of the argument in Mr. Kent's discussion of my paper.

1. Mr. Kent tells us that occasionally he reads a little philosophy himself. Unfortunately, he has not kept himself abreast of the times and has been led into the error of mistaking his own ignorance of recent philosophical development for a general loss of interest in the subject. Within the last fifty years we have Huxley, Spencer, Ritchie, Green, Caird, Bosanquet, Ward, Dewey, Royce, Pierce, Bradley, and a host of German and French philosophers of the Hegelian school, to mention only a few of the greater lights. You may be surprised to find Huxley's name in this list, but Huxley has been second only to Spencer in recognizing the essential relations of science and philosophy, and in interpreting for the masses the great movement inaugurated by Kant and Hegel. Darwin, too, has much to say in this connection. (Mr. Kent might with profit read Ritchie's

"Darwin and Hegel.") Where, too, from Mr. Kent's standpoint does he find room for the monistic tendency of modern science, or the idealistic utterances of many of our greatest investigators?

I regret to hear Mr. Kent use the term "fashionable" in connection with philosophy. Fashionable are those things which a man of sense wisely shuns. Philosophy was never so popular as it is to-day. Witness the deep effect which the growing philosophic attitude of the masses has had upon religion. Think of the crowded halls where James and Pierce have given a popular trend to the Pragmatic movement. Remember the butchers and the tradesmen who left their stalls to hear Professor Fischer lecture on the deep problems of life!

2. Mr. Kent takes issue with what he terms my dogmatic statements. I do not claim any originality for my paper. It is my purpose to bring to your attention some results deduced by a few of the great thinkers of our age, which, it seems to me, apply with great force to the problems of education. As for the category of change, I believe that Mr. Kent would benefit by a study of the chapter on "Change and Becoming" in Ladd's "Theory of Reality." If Mr. Kent has discovered any object whose nature is defined by any relation to our conscious activities that is not subject to the general order of change, then he deserves a place among the immortals, for he has done something that no other man has been able to accomplish.

Lastly, Mr. Kent's quotation of "toothache" and "corns" as a refutation of the desirability for fuller

consciousness of the world, illustrates the very error that many people of materialistic tendencies are likely to fall into. Life is to be regulated solely to avoid the disagreeable. Our organic desires are to constitute the sole sanctions for our actions.

This is quite true of a purely animal aggregate of individuals, where consciousness has only reached the hedonic stage, and where the pleasure-pain contrast furnishes the governing impulse. But in society, the reverse is often the truth. Our desires must be regulated in the light of the higher ethical action of *right*. To win the good, we must often accept the bad. The inhibition of pain at all costs is well enough for children, but I am not arguing from their standpoint. I base my assertion on what we find true in the higher reaches of humanity, and to prepare us for which is in fact the aim of education. The fuller consciousness as a means of self-realization carries with it much that is disagreeable. But the saint is never merely innocent. He has met and suffered the deepest evil, and so only can he taste of the good. Pain, in fact, is the great schoolmaster.

I think it is of importance to lay before you some data bearing on this question of professional purpose that I have collected during the last two years. I find in my records fifty-three cases in which the question, "What do you expect to do in life? What purposes govern your conduct?" was put to professional men, selected at random, under forty years of age. Of course the question was not necessarily put in the words here given, for in many cases the mere unexpected prodding of such a question would act as an

inhibitory stimulus. The matter was approached in the course of conversation generally leading up to the subject in a natural order.

The replies were widely at variance with one another. Of the answers, forty-seven may be generally classed as indicative of a lack of ability to see any evidence in the world of more than a hopeless struggle for mere existence. The range lies practically between two extremes—commercialism, so-called, and absolute callousness. The first extreme may be illustrated by the desire for money, merely as such, the profession being looked upon as a convenient means to this end. The other extreme is well exemplified by an answer which I shall give in spite of the terms in which it was couched, as it expresses perfectly a certain attitude which is not rare—it is "How . . . do I know?"

Of the remaining *six* replies, three showed at least a desire to formulate some adequate answer, and indicated great perplexity of mind, while three were from men who had apparently learned the great lesson of life and were actually profiting thereby.

I do not intend to generalize from the replies given above. They are perhaps not complete or may be due to a misunderstanding. Evidence is not lacking that a more general interest in this matter is being aroused—witness, for instance, several of the later papers by Oliver Lodge, Haeckel, Tate, Ray Lankester and others.

The general point I wish to evidence is that there is a more or less acute failure on the part of many individuals to discern in facts an example or imitative copy for conduct.

After all the idea of efficiency is the ruling impulse in life. The ratio of "output" to "input"—the ratio of what we give to the world to what we get from it is the sole criterion of success. The answers, I think, furnish a pitiable example of how little thought is given to the output term of the formula for efficiency. There is next to no consideration of the fact that we better the world only in so far as we give that which is best in us.

As I stated in my paper, the deepest aim of the scientist is that of organizing experience in such a way that it can be made the object of our conscious activities. Nature is a hard taskmaster, and we live only by so modeling our conduct that it will accord with her modes of behavior. If we do not thus aim to find in nature the embodiment of our own purposes, we simply cease to be a factor in the world's progress. Necessity is the chief agent of accommodation, and the practical man living in close contact with his natural environment must be able to meet the conditions and make himself part and parcel of the natural order. He must be willing and able to control and inhibit his national tendencies to this end. Does it not seem evident therefore that rather than permit the developing individual to progress merely as his impulse dictate, that his training should be such as will organize his mental habits under the strictest self-control? I believe that we need rather a return to the educational discipline of our forefathers than any loosening of the bands of compulsion. There are errors no doubt in the older systems of education, but it seems to me that the errors lie rather

in the approach than in the form. Education is, primarily, a preparation for life, but life is governed by necessity, never by desire. The scope for selection in the actual world is very limited. A man is usually so placed that he must make the best of conditions and not waste his time trying to alter them.

How, then, are we to train the youth so that he will be able to meet and assume later the conditions of his environment? By so organizing our methods of teaching that they will imitate the processes of life by which the world of knowledge has become just what it is. The world is not there to prove the validity of textbook formulas. On the contrary, these formulas express, for given purposes, the meaning of forms of experience. Forms given to experience because the eternal process of trial and error called evolution has shown them to be beneficial to race development.

Experience comes first in life as it should be in preparation for life. Under the lash of necessity, and guided by his teacher, the student should be compelled to analyze experience for himself. Thus through the reaction between habit and accommodations his attentive interest will be aroused, and development will be completed as it began under natural conditions. Habit has been the keynote of technical education—and it is all wrong. Habit is the tendency to repeat the reflexes that natural selection has chosen as expressive of hereditary impulses. But man needs more than this. In volition he has a key to the eternally novel in experience, and volition arises through the breaking down of habits under the influence of accommodation.

The question now before us is, how should we modify our present methods of technical education to meet these problems. Remember that we are to train the student to accommodate himself to the new in experience. It is the problems of tomorrow that he must learn to master, but he must also be made to see how these problems arise from the past. He cannot properly understand them unless he can grasp the general trend of their development. His is the business of interpolation. Knowledge is behind him. Theory, the throbbing artery of experience, is to project the curves of development into the future. To know what to do next the student must know what has been done. To properly interpret the meaning of the new in experience, give it its correct classification, he must be able to pick up the separate threads of his knowledge and hold them each together in the unity of a single apperceptive span. This I have tried to make evident in my paper.

For this reason, if none other, I believe that the history of the development of engineering should form a material portion of our studies. The student should never be allowed to take up the new till he has been able to infer it from the past, or the new should be taught as an integral part of the old.

As I have earlier said, experience should come to the student in the crude, just as it will in after life, and *not* from textbooks. Let him place it if he can. Show him how experience is organized if you will, but never, unless in the last extremity, furnish him a copy that he can imitate, part for part. The world is not a laboratory where everything needed is close

at hand. Man must do the best with what he can find. Make it necessary for him to devise means to an end. Then when he has attempted a solution, aid him to find what is a true or a better solution. In other words, from first to last develop the student's originality. Further, make the student prepare his own textbooks. My observation is that the printed text serves for very little more than a source of income to the writer. The average student remembers only what he has been compelled to think out and write down for himself. His textbook should be adapted to his own individual needs.

These are merely in the way of suggestions, and I do not doubt that some of them may seem impractical. But it seems to me that we are facing an acute situation. Our schools must be adapted primarily to meet the actual needs of mental development. The science of psychology is too far advanced for us to ignore it. Our educational systems must be organized so that they will not run counter to, but will apply, the laws of conscious evolution.

So much has been written on the organization of the teaching staff, that it seems quite hopeless to state anything original. I can only attempt to accent what has of recent years become a settled conviction among adequate judges. The head of the department must be a man thoroughly conversant with the actual life of his profession—not a mere academician, but an individual of wide, practical knowledge. His principal duty is to outline the course and instruct his assistants. The assistants are to be men chosen not merely on account of their desire to teach, but on

account of their ability to teach. Teaching is a profession and a most difficult one. The teacher needs more than engineering knowledge, he must also be trained in the rudiments of his own profession. Now I realize the difficulty of procuring men of this type, and I therefore desire to suggest that room be made in your faculties for a trained educator—a man who has risen through the ranks—preferably drawn from a high school—a psychologist—a student of mental and moral development—a logician—a philosopher. His lectures on applied logic and metaphysics should follow the course in natural physics. He is to teach the students to criticise their own conceptions—to analyze their own experience.

I have been asked to mention some textbooks on logic and philosophy suitable for use in technical schools. You have my opinion of textbooks in general, and I can only add that I see no necessity for their introduction, except as reference works to which the student may be directed for a more detailed elaboration than can be attempted in the classroom. I am free to confess that at present I know of no work, either in logic or philosophy, that has been drawn with direct reference to this end.

My own idea is that until this want is filled, "The Spirit of Modern Philosophy" by Josiah Royce, Jevon's "Logic" as revised by Hill, and Erdman's "Outlines of Logic and Metaphysics" would prove interesting and valuable reading for the student, while Baldwin's "Mental Development in the Child and the Race," and "Social and Ethical Interpretations," together with Royce's "The World and the Individual,"

should be in the hands of every teacher. The "Principles of Logic," by F. H. Bradley, is perhaps in the main as true a formal exposition of the operations of our thought as has been written within the past twenty-five years, although more suited to the needs of the teacher than the needs of the student. For an able and stimulating criticism of the fundamental conceptions of science I would suggest Ladd's "Theory of Reality."

A man does not learn to think accurately by "browsing around in books." He learns to think by example and necessity. Logic and philosophy are systematic summaries of racial mental attitudes. Produce the attitude and philosophy follows as a matter of necessity. The courses in logic and philosophy ought to be incorporated into the general structure of the teaching system. Stress should be laid upon the fact that knowledge hangs together on systematic thinking, and that science is the expression of such thought.

If you adjust your methods of teaching to the order of development of the brain functions, and seek to develop the apperceptive powers so that the experience stimulates desire and effort, the student will want to learn, and your battle will be all but won. The crying need of modern technical education is not better laboratories, but better teachers.

ENGINEERING EDUCATION BEFORE AND AFTER THE WAR.

BY J. BURKITT WEBB,

Professor of Mathematics and Mechanics, Stevens Institute of Technology.

This paper, and no doubt many others, you owe to the effort and tact of your excellent Secretary. He sent me two things: a list of one hundred suggested subjects, so many of which would have suited that nothing would have been written, and a personal letter asking for a historical paper with reminiscences, telling the younger men the trouble of getting an education in my younger days and something about the "giants that there were in those days." It was easier to say "yes" than "no" and a title was hastily chosen, which we must now try to justify.

To see if the Civil War had any noticeable effect on technical education, a graphical table of technical schools was made with the years of the last century as abscissas and the number of schools in the United States in each year as ordinates and a logarithmic curve was drawn. There is a slight depression or break during the war and the increase is very rapid after it, but the main variations are perhaps from financial causes.

My own education was commenced before the war and finished after it. In Professor Baker's presidential address* before our Society he speaks of there being six such institutions before the war, but there

* PROCEEDINGS, Vol. VIII., p. 11.

were others, not to speak of various mechanics institutes and trade schools. My father belonged to the Franklin Institute and took the *Scientific American* from its commencement, which was a pretty good school in itself, and it would be a mistake to take the limited number of prominent schools with engineering courses as measuring the possibilities of such an education. The fundamentals were taught in many places and it needed only a *natural aptitude, singleness of purpose* and a *strong will* to get as good an engineering education then as the majority of students get now. During my connection with Cornell University old Dr. Wilson said in faculty meeting that he had never known a promising and worthy student fail to obtain his degree for lack of funds, so that the education depended on the qualities above mentioned.

The difficulties to be overcome, though different, were no greater then than now. In those days no one thought of making mahogany furniture without the wood, but now birch, spruce, and even bass and hemlock, are sent to the factory and a mahogany certificate attached to the product. If a boy had no natural aptitude for an education, there was little chance that his parents would insist on his having it, especially an engineering one, which was not then fashionable, so that the material for making engineers was better then than now. While much of our present material is good, much is bad, and the demand for mahogany furniture is such that the fact that there is not enough of that wood is a minor consideration. The engineering profession has grown and blossomed

in a wonderful way; wealth and influence are siding with it and boys lacking *aptitude, purpose* and *will* must be made into engineers. The difficulties of getting food, shelter and raiment may not exist, but dangers more formidable block his path. Fortunate he who still has the old difficulties and not the new dangers. Give me my choice, and it will be for the earnest atmosphere and single purpose which was the rule formerly.

One might like to wake up in a century or two and have a look at things, but what will it be to live when everything has been found out or when any one mind can take but a bird's-eye view or when the simple laws and facts of mechanics have perhaps been discredited by too much knowledge.

But what were the chances for a scientific and engineering education before the war? Then, the scientific predominated; now the engineering courses often have too much of the trade-school in them. The impression that Professor Helmholtz made upon me will never be forgotten. He came into my room to discuss the investigation of alternating currents that he had given me to make and it was natural to pick up some wires and use them to illustrate the circuit. Involuntarily he showed his disapproval, his mind resented the recourse to a model, the material forms were a hindrance to his imagination.

We now have an immense quantity of apparatus for engineering instruction because of deficiency in that *natural aptitude* which some call genius. In the early days of education, apparatus was scarce to the great strengthening of the imagination and increase

of that aptitude. Without the aptitude, students were not likely to seek the engineering courses; now, they are attractive for other reasons.

Your Secretary asked me to tell you of the difficulties which existed in my youth, but I seem to be brushing them away, and it is a good way to treat them. The hydraulic engineer dams up a stream to make it useful and difficulties that dam up a student's energies just the right amount give him horsepower without which he is to be pitied.

In the matter of aptitude, the present is no better than the past; for while there may be actually more there is less in proportion to the now larger field for its exercise. Natural aptitude or genius is largely the result of an unconscious or subconscious education, without which other education is apt to fail. I was favored in this respect. My father was an inventor and I breathed that atmosphere. His chest of tools was to me a box of wonders and I longed to use his lathe myself. I had a beautiful little brass steam engine and he made me a cardboard one that ran by blowing into it. Three of us boys had a chemical laboratory near our grammar school and when the principal died he left me his philosophical apparatus which I set up and used in a spare room at home. When my father built a large windmill, I built a small one. He helped me make an air-pump, by thinking that I could not. I was never tired of looking through his boxes of "jim cranks" and some curved glass tubes with shot in them excited my suspicions, they suggested experiments in perpetual motion, and he avoided explanation. The clockmaker's

window on Front Street exhibited three such motions in operation, so that it was not a lost art at that time.

So with tools and apparatus that we should throw away as rubbish or out of date, I grew up, and my grandfather shook his head and said I'd never make a business man. But it was the best kind of a scientific education. Would more apparatus and better tools and more encouragement have been better for me? Well, there is a great stimulus in having just enough to satisfy the taste without surfeit and make one wish for more, and I knew when a thing was done right without being loaded with praises, so I was left to find out some laws and principles by instinct, for a natural law is only that simple view of phenomena which harmonizes all the facts.

I was sent at thirteen to the excellent Philadelphia High School and with my aunt's advice chose a classical course, but in spite of high marks in scientific subjects, my general average was not up to my father's high standard, and he took me away before completion of the course. If there is any criticism to be made on that part of my education it is that I wish some way might have been found to make me understand the value to the scientific man of just those branches of general culture that I was disposed to neglect. I found it out later and tried to remedy the defect.

Three quarters of our students now have not the general and linguistic culture, with the maturity of logical power that goes with it, to make it possible to teach them anything thoroughly in a reasonable time. If a student is worth educating at all he had better

begin with four years of a regular college course and take as electives as much science as he can digest and then a better engineering course than we give now could be finished in two years more; he would then also be able to choose better what engineering course to take. All the classical students in my classes have justified this view and at thirty the man will be farther along in life and better educated.

At seventeen, I rebelled somewhat at the mercantile life with my grandfather and discovered for myself the Philadelphia Polytechnic School or Institute. Penetrating to the president's office and stating my desire for a technical education, I learned the conditions and possibilities and did my best to persuade my father to let me undertake a civil engineering course. But tuition was not free and he did not feel sufficiently sure of the result so that I had to give up immediate hopes of it.

Previous to this I had formed my life-long friendship with Oberlin Smith, who has since won a national reputation and who was then a young giant in his line. We loved the same things and when either got a vacation he visited the other forty miles away. My trunk was always ballasted with iron and brass, apparatus and tools were in the bottom of it to show to him. Now I am not talking about myself, but about an engineering education and the difficulty of getting one before the war, and one of the greatest difficulties was carrying that trunk on my back up the hill to his mother's house. After that we had a technical school over his and my treasures all to ourselves. Sometimes one taught and then the other and the pupils

didn't lack for aptitude. From fourteen years old to twenty we made our own apparatus and gave our own lectures and demonstrations, and such is the history of the education of many a man who thus and then learned more than would be thought possible now, for what we lacked otherwise we made up by imagination and reasoning. Before coming of age I ran away from the mercantile life with my grandfather and we attended night school together for drawing, descriptive geometry, etc., after which we formed the partnership of Smith & Webb and had over five years' experience together in the machine business. Now would it have been any better for me to have gone instead to one of the six schools mentioned by Professor Baker instead of having this experience in business? I understand that some of you now propose to give instruction of this kind in the regular course to teach how to handle men and practical problems. My advice would be to confine the course to its legitimate ground and cover those things that a man will have little chance of learning later.

Nothing has been said so far about books. They could be had and good use made of them. Books, however, were not thrust upon one, as they are now. They were more modest and waited to be asked. The "Encyclopædia Britannica," then rarer than now, was in my grandfather's library. My father had "Appleton's Cyclopædia of Mechanics," etc. My aunt had French books and "Silliman's Physics" appeared at Christmas. We used "Davies' Descriptive Geometry," one of the excellent textbooks given us by West Point men. One book of my aunt's was fas-

tened on to as my own and has been brought with me, thinking all may not have seen it.

Technical education started sooner abroad than here and in spite of what many good people have against the army and the church, both have been very useful in the matter of books. Engineering originated largely in the army and culture in the church, and some of the best scientific treatises have been written by military officers or churchmen. Particularly in France, treatises were prepared for government schools and as such had a definite scope and aim. The book I have is, however, in English: "A Course of Mathematics Composed for the Use of the Royal Military Academy," by Charles Hutton, LL.D., F.R.S., late Professor of Mathematics. Corrected and revised by William Rutherford, F.R.A.S., Royal Military Academy, 1840.

It was written about thirty years before, and, as may be seen, they had a very correct notion of what mathematics should be taught and how to teach it.

I have an affection for this book. It was printed the year I was born and I drank in the milk of differential calculus mostly from it. I had attempted at sixteen to discuss mathematically the principles of the windmill my father patented, and had so far invented for myself the usual method of finding maximum and minimum values as to be able to calculate the proper speed for maximum work. The method seemed so powerful and important that I felt instinctively that there must already be some such branch of mathematics. I set to looking for it in Hutton and found the "Differential Calculus" which till then had

been no more than a name. It was like reading a novel, except the differentiation of a^x. Then it referred back to a whole page of series on the exponential theorem, which took my breath away and I left that theorem out until four years later, when visiting a son of Judge Rodgers, of Springfield, Ohio. He had been to college and his Loomis's "Calculus" had a simpler treatment, which removed all difficulty.

Before the war then there was the same chance as now for any one to learn the fundamentals of engineering science that had the *aptitude, the purpose* and the *will.*

After the war a regular course in college seemed more and more desirable provided my mental capacity was equal to it. One of my grandfather's maxims was that "a rolling stone gathers no moss," and it was hard to decide to sell my share in Smith and Webb and go to school again. To test my mental capacity, I set myself the task of learning verbatim the introduction to Loomis's "Calculus." That settled it and I had to choose between Harvard, Yale, Rensselaer and the University of Michigan. Catalogues were studied on the principle that the higher the entrance requirements the more the course and the diploma would be worth, so that admission granted the more entrance conditions the better, and being February there would be a semester's conditions anyhow. The University of Michigan was chosen as being the farthest from Philadelphia, so that if not suited any change would be toward home. Providence favored the choice and friends sent me letters of introduction to Dr. Gillespie at Ann Arbor

and later Bishop of Michigan, and to Professor De Volson Wood, which made it easier for me to get started and the sale of my business interests gave me much more than was needed for a college course.

Had your Secretary asked me to write about the difficulties of getting an education to-day, more could have been found to talk about, for it seems to me it was easier for the average student then than now. Then we finished geometry with the sphere and ellipsoid and went on to other and higher subjects, but now these simple bodies seem to dominate the college life of many students, who devote their energies mainly to violent practical discussion between themselves and other colleges over the simple position of these bodies in space. Blessed is he who works his way through college, with no time or money to waste.

As to the giants of those days, one is enough for so short a paper; indeed, a paper apiece would do them less than justice, and if more is wanted on this point it must be left to the future.

ENGINEERING CHEMISTRY OR CHEMICAL ENGINEERING.

BY CHARLES F. MABERY,
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The school of science is founded on a two-fold assumption. First, that the individual receiving its benefits has the intellectual capacity to assimilate its training with adequate improvement of his mental condition, and with the corresponding capacity to acquire a store of knowledge that will be useful in the practice of some branch of applied science. For the satisfactory accomplishment of this design, the youth is permitted to devote the four best years of his life to such preparation for professional scientific employment, after he has received according to the wise judgment of those in charge of the scientific curriculum, a suitable preparation in the secondary schools. It is further assumed, that the individual has the ability to make an acceptable and successful use of his attainments, a feature of the first importance in modern education, since the present demand is for the man who can show results to the practical exclusion of his opposite. In this respect the institution, unfortunately, has no means of protecting itself from a waste of time and energy in educating an individual who can mentally comply with its requirements but who lacks inherent energy and ability to benefit by his attainments. It has no data whereby it may determine whether the

applicant is a born genius, the like of whom we have all known, who, with scarcely the rudiments of an elementary education, can master with proficiency any mechanical process, wood or iron work, fancy painting and decorating, photography or designing, or whether he possesses so little of practical application, like persons we have known, with the ability to master any literary subject with the greatest ease and proficiency, but who can scarcely make sufficient use of their knowledge for personal maintenance.

It is not on either of these extremes that the school of science must depend for a justification of its work, but rather on a well-balanced mental equipment that leads the individual to select a mode of action sure to accomplish the desired end. It may be that educators who have been long occupied in preparing young men for professional employment often feel that the proportion of such individuals to the entire student body is not large; perhaps they are led to share in the belief often stated that many a good farmer or mechanic is lost in the making of a mediocre engineer: in other words that the schools are attempting to educate too many men. But on the other hand, with the present omnivorous demand for scientific men, it does not seem possible to set close limitations. In the intelligent arrangement of its duties the institution can only adapt itself and adjust its work with reference to the demand of the industrial and economic situation of its environment. In our own country this doubtless includes a broader scope of intelligent applications than in most others, by reason of the great expansion of our multifold

resources, and the immense storehouse of vital and mental energy in this section of the north temperate zone. The successful individual must be able to decide quickly and accurately with reference to a systematic course of action, and possess a power of physical and mental concentration in the use of the mechanical and human agencies at his disposal that cannot fail to reach the desired result. Evidently this situation demands of the institution an expert knowledge of economic conditions, and the means to provide for them in the details of its organization.

After his preparation for admission is accepted, the institution has pretty complete control of the conditions in which it places the student, and is able to apply its expert knowledge and judgment to the best advantage. Successful training in chemistry is, perhaps, more dependent on personal characteristics than any other branch of applied science; and it is doubtless true that more time and attention are required in securing a grasp on the inner spirit of chemical changes and the conditions under which they operate. Delicate touch and skillful accuracy in manipulation, alertness and instinctive watchfulness in observation, a prescient insight and a cautious yet confident interpretation of results and conclusions demand years of training even of the person with natural endowment, and no one who is lacking in this direction can hope to reach a high attainment in chemistry such as is essential in professional occupation.

It is eminently suitable to require a comprehensive and thorough training in the principles of chemistry in all courses in engineering for two reasons; every

person should have practice in manipulation to acquire manual dexterity, and in the study of chemical changes and inferences involved, for training in accuracy and observation. It is also of importance to the engineer to be acquainted with the quality and properties of materials, and chemical principles involved in construction and operation. Beyond this it is scarcely possible for the engineer to continue profitably the study of chemistry. There is no doubt, as is often stated, that incidental knowledge is useful, but the time of every student is now all too limited to secure what is absolutely essential in his particular field. For instance, it is urged that a mechanical engineer may find quantitative analysis useful, for the principal reason of the training in accuracy; but he should get this in physics; he can never make quantitative analyses himself on account of lack of time; and it is not possible for him to devote sufficient time to laboratory work to acquire such skill that he can pass critical judgment on the work of a chemist with reference to its quality.

It is not long since the term chemist was synonymous with analytical chemist, a graduate from a course in which chemical analysis was the principal feature, who spent his time in the laboratory of the manufacturing plant. In the control of manufacturing operations, the quality of crude materials, the progress of operation, and the standards of shipments, chemical analysis is at present more depended on than ever in the history of manufacturing industry. But analysis is in the hands of routine workers on moderate salaries, whose principal duty it is to arrive

at correct results as soon as possible. The ambitious chemist whose training has fitted him for more responsible duties remains in the laboratory only long enough to get his business bearings. Numerous questions requiring a broad expert knowledge are constantly brought to his attention; the conduct of operations demands his oversight; exploitation of improvements and new processes, expansion of business and the conditions of the outside manufacturing field, are all matters for his consideration. New plants must be erected, plans devised for machinery, old machinery repaired, with economical operation in every detal. Production of power must be reduced to the lowest cost and the most complete utilization with reference to facility and operation, and rapid accumulation of finished products. The application of heat and of electrical energy in bringing about chemical changes, as well as in the economical production of power are subjects that the chemist must understand fully.

The question suggested for our consideration refers to what shall constitute suitable training in chemistry, and what subjects shall be included for thorough mastery in the limited time of the accepted course at present in operation in schools of science. As to adequate training in chemistry for professional occupation, two features present themselves for consideration; in the first place the student must acquire a correct and comprehensive understanding of what a chemical change means, with its attendant conditions, physical, chemical and economical, as a foundation for any manufacturing process in metallurgy, or in

the inorganic and organic fields of applied chemistry, including sanitary chemistry and bacteriology relating to the fermentation industries. He must understand the valuation of fuels, gaseous, liquid, and solid and their economic uses. The courses imparting this knowledge in inorganic, organic, analytical, physical and theoretical chemistry, must occupy the principal share of the student's best attention, and this work cannot consistently be abbreviated without narrowness.

With this situation with reference to chemistry, the second question as to the introduction of courses relating to the engineering feature is an embarrassing one; it may be answered in one of three ways: (1) eliminating some of the chemistry, (2) retaining all the chemistry, and requiring additional work in four years, (3) Extending the time of the course beyond present limits.

A solution of this problem has been sought in most institutions by offering a course in chemical engineering, made up of a part of the regular work in chemistry, and a part of the course in mechanical engineering. If the student comes to the institution with a well-defined plan as to his profession, and what specialty he will adopt, such for example, as Portland cement, soaps, or dyeing, he can secure sufficient preparation in chemistry to meet his wants, without the breadth of a complete course, omitting portions of the subject not directly concerned with his proposed line of work. But he is beginning to specialize too early before he can form an intelligent idea as to his particular qualifications, or as to what field may seem to him most promising when he

is ready for business. He must be prepared for the most encouraging outlook whether it be along the lines of organic or inorganic practice. Then, besides the feeble attempt toward specialization in the preparation of a thesis, he has no time to specialize during his undergraduate course. Specialization comes in the practical application of the knowledge he has acquired when he is called on to make use of results which will demand his best thought and information in abstruse business problems.

It is possible that students with ability somewhat above the average may include creditably the entire course in chemistry, and introduce the necessary features of electricity and mechanics in four years, but the average student finds this task beyond his range, The chief element of difficulty is the great amount of laboratory work in chemistry that cannot be abbreviated especially with the modern spirit of students which demands that they be taught; they learn only so far as they are under compulsion. It seems to be the common experience of teachers that students are more and more falling into the attitude that they have nothing to do but follow the detailed direction of the textbook or the teacher, and the set regulations of the institution for graduation, as close to the minimum requirements as appears to be safe. From statements of eminent educators I learn that this condition is as general in colleges and universities as in schools of science. Students cannot be taught chemistry; they must learn it by practical persistent study of phenomena. For the reasons above set forth, it seems scarcely possible for the student to receive adequate

training in chemistry if a part of the time that should be allotted to it is taken up by other subjects. Since it does not appear that the average student is able to carry the combined course in the usual time of four years, the inevitable result seems to be an increase in time. A fifth year would be eminently desirable but at present it seems to be out of the question; yet it is possible to add to the time devoted to laboratory work, which is the first requisite, and which really needs more time than it now receives.

From remarks on this subject by various teachers of chemistry, I conclude that the feeling prevails that the course in chemical engineering now offered by institutions is deficient in the direction outlined above, and that the situation can be improved only by extending the time of the course, especially those portions devoted to experimental study in chemistry. I have also reason to believe that this situation is recognized within the institution with an inclination toward additional time for experimental work. With reference to the name of the course it matters little, provided it contains sufficient chemistry. In the course as now offered, I question whether it does. If chemical engineering means that the principal features pertain to the engineering subject, it should then be classified as an engineering subject with a distinct understanding as to its object, and that it does not pretend to give full training in chemistry. The term engineering chemistry which has been suggested as pertaining more to chemistry as a foundation, is not inappropriate in classifying the course on the basis of chemistry. This term defines the

expanded course as the original course in chemistry, which evidently should not be sacrificed and not materially changed in its general methods, but containing in addition the necessary training in mechanics and electricity.

For several years before extending our course in Case School, I advised the brighter students to take several subjects in mechanical engineering and electricity, and it was found that by little extra exertion they could carry those subjects with creditable standing. I then consulted with several eminent specialists in manufacturing industries dependent upon chemistry and I learned from them that the deficiency in mechanical knowledge of their chemists they were obliged to supply through their mechanical engineers. But they confidently asserted that it would be a great advantage to them, as well as to the chemist himself, if he were able to take care of the mechanical details as well as the chemistry of manufacturing operations, that it would be perfectly feasible, and that it would add greatly to the efficiency of the ordinary course in chemistry provided there was no material encroachment on the time devoted to the regular work in chemistry. With our present arrangement which gives the student the benefit of a considerable extention in the time spent in the laboratory, the average student is able to carry all the work in chemistry, together with thermo-dynamics, applied mechanics, hydraulics, heat and steam, practical work in the shop with the steam boiler and engine, and the use of testing machines. The training in electrical engineering includes direct and alternating currents, the use

of dynamos and motors, with laboratory work in testing and the uses of electrical currents. This seems to be about as near an ideal course as can be devised, for it gives the students practice along just the lines of work that fall to him when he goes out into business. During the two years of its operation, the results have been eminently satisfactory both as to the interest shown by the student and the evident breadth he acquires in the mechanical subjects.

As an example of the operation of this course, I ask your attention to a thesis on the manufacture of Portland cement presented this year for graduation, which includes a complete drawing to scale with every detail of a plant devised for an output of 2000 barrels daily, with calculations of the efficiency in every part of the plant, and selection of the most improved machinery from designs of the manufacturer. In the preparation of his thesis, the student had the advantage of the wise council of Professor Newberry of the Sandusky Portland Cement Company, and free access to all parts of their works and to those of another plant of equal capacity. Besides the knowledge gained from these sources, the student collected data and descriptions from all available literature. He included in his work the compositions of the clay and marl, methods of testing the finished product, compositions of the mixtures, of the burned clinker, and other details of the chemistry of cement, including a study of White Portland, now manufactured extensively in Germany and under consideration in this country. Directly after graduation I was able to offer to this young man two places, one in a Port-

land cement factory, just in the line of his preference, and another dependent on a knowledge of organic chemistry. Naturally he chose the place in the cement factory, although he would have taken the other position if this only had been offered and he would have been well qualified for its requirements.

AN EDUCATIONAL EXPERIMENT.

BY WILLIAM G. RAYMOND,

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During the past year an experiment in individual instruction has been made in the State University of Iowa. A statement of what this experiment was and some of the observed results is the purpose of this paper.

At the beginning of the year, notices were posted asking for volunteers from among the civil engineering students of the freshman class to form a section to be taught individually. The section was limited to twenty men, and after full explanation of the plan the entire number—about one half those entering this course—applied and were admitted.

The composition of the section was peculiar, as may be inferred from the several reasons for joining the section given by those who applied. Some of these reasons were:

1. The hope of getting through the year's work earlier than the regular class to secure longer vacation employment for needed self-support.

2. Belief that the instruction would be more thorough than class-work.

3. Greater freedom in selecting hours for employment necessary for self-support.

4. Fear on the part of one or two mature men that the lapse of time between high school and college

courses had been sufficient to make satisfactory progress with regular classes doubtful.

5. Desire to offset a known lack of moral courage to study by constant supervision in the class-room during study periods.

6. Possibility of working off entrance conditions by attendance on college classes or in the local academy without program conflict.

One or two men dropped out or were dropped at an early day and their places were filled by late arrivals, making a seventh reason for selecting this method.

The ages of the men ranged from seventeen to twenty-five years.

The conduct of the section was far from what it would be under a regular system of individual instruction, because it was impossible to supply instructors who could give a half day regularly to the work. In the second semester, in particular, difficulty was experienced that reduced the efficiency of the work considerably below what it may be under favorable conditions.

Because of inadequate instructional staff, it was found necessary to abandon the original plan for doing the English work by personal consultations with the instructor, and to include the individual section with one of the regular sections.

The mathematics suffered the second semester, for, although an excellent instructor was in charge, he had other work to do and the class, freshmen be it remembered, failed to utilize the time during which they were left alone any better than any other lot of boys would have done. Besides this, two morn-

ing periods weekly were used for class work in English.

Some of those who feared they would not have moral courage to study except under direction proved the correctness of their self-knowledge by failing to develop sufficient moral courage to attend class regularly. While these students were warned of the consequences, the action that would ordinarily be taken, namely, the exclusion of the student from further attendance after a maximum of unexcused absences, was not taken for two reasons: first, the class was a volunteer class, and this fact made it seem undesirable to deprive any man of the privilege of completing anything he might be able to do, however limited his attendance; and, second, it was desired to learn all that could be learned of the details to be looked out for in conducting work on this plan.

The whole class was of necessity confined to one room, no matter what subjects were being pursued. This was a distinct disadvantage, for while the greater advancement of some men in a given subject proved something of a spur to the slower ones, the earlier passing of one to manual work—as drawing—in the same room, was demoralizing, those students lacking somewhat in self-control and concentration finding altogether too much of interest in their neighor's work.

In spite of the many difficulties, the section as a whole completed the same proportion of a year's work that was done by the regular classes. Indeed, it did much more than the regular sections did, because in mathematics every man worked from two

to ten times as many problems in a given subject as the men of the regular sections worked. For instance, every man who completed the subjects solved 1000 problems in algebra, 300 in trigonometry, and 400 in analytical geometry.

Chemistry was the first subject undertaken. The theoretical work was conducted by an instructor in chemistry who was with the class from eight to twelve every morning, except that three times a week the section attended the one-hour lecture given to the regular class. Every afternoon was devoted to laboratory work in chemistry, and two to three times a week the regular students were present as well, making the laboratory too crowded for rapid work.

As soon as any student finished theoretical chemistry he devoted his mornings to algebra, having the full time of an instructor in this subject to the end of the first semester, before which time the quicker students had finished algebra and begun trigonometry, and one had almost completed the latter subject.

When laboratory chemistry was completed, the student devoted his afternoons to drawing until this was completed when he began descriptive geometry. For these two subjects the full half-day time of an instructor was available, in spite of which some men failed to reach the descriptive geometry, and over half failed to complete it; but the record in this subject for those who undertook it was distinctly better than in the regular classes.

Some things of interest, perhaps not new to the trained pedagog, were noticed.

The rule was proved that while a man may have

his special line of work, the normal man is either good, or poor, or average, in everything; the abnormal man can do one thing much better than another. The man first through in chemistry theory failed utterly to master algebra, and dropped out. The fourteenth man to finish the theory of chemistry was second in time required for algebra.

Of the two men who finished the year's work three weeks before the close of the year, one worked like a slave night and day and seemed to enjoy it, while the other was partly self-supporting, played in the band, did the equivalent of one and one sixth years of college work, and always seemed to have plenty of time.

One man, it was thought for a while, would never master descriptive geometry, and had he been in a regular class would undoubtedly have failed, because before he began to see it at all so much time had elapsed that a regular class would have been far beyond the possibility of his catching up with it. But once he had it, he went ahead by leaps and bounds, and finished well within the allotted time. Other men, fully as able as he, failed utterly in the regular classes and dropped out early in the course.

Two men had been in college during the previous year in regular classes and had failed so completely as to be required to repeat the entire year. Both these men were self-supporting. One, a faithful worker, but not quick, easily discouraged, required encouragement to keep him at work after a failure, passed the entire year's work satisfactorily except the one subject of English taken with the regular classes.

The other, a bright, quick, erratic fellow, suspended for the better part of one semester as a matter of discipline, completed the equivalent of the year's work with something to spare.

The race for good standing was not always to the quick, nor yet to the slow; it was sometimes to one, sometimes to the other, and sometimes to neither, but it was usually to either a quick man or a slow one, rarely to the man of average speed who generally secured an average grade. In drawing, only two men received the highest grade given; one did the work in less than two-thirds the regularly allotted time, the other used more than the regular time; there was but one man quicker than the first, and no one who did faithful work who was slower than the second. The only man to receive an "A," the highest grade, in theoretical chemistry, was the third in point of time required, while the only man to be similarly graded in laboratory chemistry was the slowest, requiring about seven fourths the allotted time of the regular classes. In algebra there were four men graded "A," and the times occupied varied from six weeks to ten weeks.

It is believed that there were two students in the section who failed to complete the year's work who might have completed it under the usual class method, but it is also believed that they would have done their work much less thoroughly.

It is believed—indeed, it may be said that it is known—that there were several students in the section who would have been entirely lost at an early stage of ordinary class work in several subjects that

were completed in most creditable fashion at a slow rate.

The university has a system of honor scholarships whereby each accredited secondary school of the state may send each year free of tuition one student selected by the home school from the upper fifth of the graduating class. There were five of these scholars in this section, three proving most satisfactory students, though only two completed the year's work. One of the others is one of those already mentioned as likely to have completed the year by the ordinary methods, while the fifth did not justify his appointment as an honor scholar.

It would seem to be wise to separate students doing even such closely related subjects as the various branches of mathematics. A single instructor should have charge of a limited number of students in a single subject, and no other subject should be under way in his room at the same time. Such arrangement may not always be possible, but is best. If it is complained that an instructor will find it monotonous to always teach algebra, for instance, the instructors may be changed from year to year, and experience seems to show the writer that a single subject, properly taught in this way, will not become tiresome in a single year.

The method is as much a test of the instructor as of the student, and many a teacher who could go on indefinitely under the ordinary class method of recitation or lecture, would soon find his Waterloo under the individual method. He must have the whole of the particular subject he is teaching at his fingers'

ends; he must be warmly sympathetic, yet able to distinguish between the need of sympathy and the need of a prod; he must know how to teach by leading the student to think logically for himself rather than by full and complete explanation, which is always easier; he must be able to dominate the atmosphere of the room, keeping it warm and cordial, yet snappy and business like; and he must be faithful to his hours, and not a time server.

The writer of this paper, both because of lack of other available instructors, and because he wished the experience, carried the section through two subjects. While the work required long hours it was not so fatiguing as either lecture or sharp quiz work, and it was by far the most interesting teaching the writer has ever done.

Four results that may be of interest are these:

1. There were only four men—20 per cent. of the section—who covered satisfactorily all the work required, and all of these could have done, and three did do more than the required work in the required time, thus setting themselves distinctly in a class by themselves, though differing greatly with each other in their methods and capacities. Only four men—20 per cent.—of the regular class in civil engineering, passed the year's work with a clean record, making this result alike in both sections. A little larger percentage—about 25 per cent— of the entire freshman class made a clean record.

2. The record shows about the same total proportion of a year's work accomplished by the individual section as a whole and the remainder of the class. The proportion was about 75 per cent.

3. The ratio of work accomplished by the most advanced and least advanced students of the individual section is as 177 to 100, and if the most advanced student had remained to the end of the year at the same rate the ratio would have been 188 to 100. In this connection it should be remembered that this most advanced student was wholly or in part self-supporting, played in the university band, which required more time than the usual military service, and was also in the regular class during the first semester, his gain being almost wholly made in the last half of the year.

4. The most advanced student would complete the regular curriculum in approximately three and one quarter ordinary school years, and would probably do it in three years. The least advanced would complete the work in six years, or possibly less. But if the school year might be, say, forty-six weeks long, the time required would be two and one half calendar years and five and one quarter calendar years respectively.

The first and second of the foregoing results seem to indicate that several classes of men taught by different methods will reach approximately the same level of accomplishment, but this interpretation is not quite correct, because the individual work was not conducted with the same relative efficiency as the regular class-work, and the true indication, therefore, is that a measurable excess of accomplishment is possible under the individual plan. The four results, considered together, indicate the extent to which the man of quick intelligence is held back to the average in ordinary class-work, and the liability of the slow

man to fail, be he never so faithful, because he cannot reach the average.

The third and fourth items seem to indicate that the quick student may get permanently into his profession from three fourths of a year to one and one half years earlier, if taught by the individual method, or he may secure a much broader education in the usual four years. It is not forgotten that summer vacation work when it is secured is valuable training, and that the proper length of the school year is an open question distinct from the question of individual instruction. The results indicated may, however, be considered contributions to the discussion of both questions.

A student expression may be of interest. At the end of the first semester there were vacancies in the section, and two men from the regular class applied for admission. One of these was perhaps the ablest man in the entire freshman class—certainly as able as any other. His opinion is worthy of considerable weight. He had the regular class training in the first semester and the individual teaching in the second. He really needed very little teaching, little more, in fact, than the assignment of work, though he did occasionally make mistakes as well as the rest. He was very positive in his preference for the individual work for three reasons: First, because he got a better working knowledge of the subject in the same time; second, because he found it agreeable to work on a single subject till a particular point was accomplished, or until tired, when he could take up another, it was a relief not to have small portions of several subjects to do each evening; third, because he could pro-

ceed at any rate of which he was capable, getting full advantage of ability and diligence, thus giving an incentive to full effort, which was lacking in the regular class-work for which he found himself doing just enough to get through with credit.

The slow, but faithful, man's reason, corresponding to the last of these arguments, would be that he finds himself able to progress as rapidly as consistent with thorough work without the danger of being carried faster than he can go with credit or of being left hopelessly behind.

A distinct advantage of the individual method, so patent that it need not be elaborated, is the opportunity given to any man, graduate or undergraduate, to enter at any time upon any subject for which he is prepared, and to follow it to any desirable or possible extent. The possibilities to the graduate student, to the undergraduate student of limited means, who can conveniently work but part of the year, and to the mature man desiring to investigate a single field, are very great, and the method in this particular seems to conform in the highest degree to the true university idea.

On previous occasions the writer has strenuously advocated before this body the individual method of teaching. He has done this without personal experience with the method, simply because it appealed to his reason as the rational way to deal with individuals no two of whom are alike. His experiment of the past year has taught him many things concerning the details of the work and has made his faith in the method absolute and unchangeable. (For discussion see page 99.)

PEDAGOGIC METHODS IN ENGINEERING COLLEGES.

BY WILLIAM KENT,
Dean of the College of Applied Science, Syracuse University.

The great advances in engineering practice in the past twenty-five years have been largely due first to the dissatisfaction of engineers and their employers with the way in which things were done in the past, and secondly, to the exercise of the engineer's brains in finding out better ways of doing them.

The work of the engineer has included the systematic study of the properties of his raw materials and of the ways in which these raw materials could be handled, so as to utilize them with the greatest possible saving of time and labor and so as to secure a maximum value of the finished product. This work of the engineer is still going on. People are not yet satisfied with what has been accomplished, and never were engineers more active in trying to find out still better ways of working. The same ideas apply to the technical colleges. Splendid as is the work they have done, no one is yet quite satisfied with them either in the kind of raw material they handle, the method of handling it, or the value of the finished product. Dissatisfaction that merely ends in complaint is of no use to the world, but dissatisfaction that leads thoughtful men to study how things may be improved is of the greatest benefit.

The technical college at present is not in condition

to control the quantity or the quality of its raw material, the high school graduate. He must be accepted with all his imperfections. The problem for the educator is to study and classify these imperfections and devise ways and means of getting rid of them, so as to make the young men better students, and then, when they have acquired the proper study-habit, to devise ways and means of giving them such professional training as they should have, in the most efficient manner possible.

Let us consider the average freshman upon his arrival in the technical college. For the preceding twelve years he is supposed to have had training in the English language. He has criticized Shakespeare, Addison and Carlyle, and yet he cannot write a good composition of five hundred words on any subject which requires the use of his observing powers. His penmanship and his spelling are apt to be execrable and his paper is lacking in neatness. His spoken English is likely to be just as bad. If he has studied a lesson, he cannot recite it in such a manner as to convey information to his hearers. As to arithmetic, he has studied that from four to six years in the grammar school, but neglected it in the high school; and he cannot solve a complicated problem in compound interest, or in mensuration, without making mistakes. His reasoning powers are supposed to have been cultivated in his mathematical, linguistic and scientific courses, but he shows a greater desire to receive information passively as it may be handed out to him rather than to use his thinking powers to obtain it for himself.

This criticism of the young freshman is not intended as any reflection either on his moral character, or on his natural mental ability. His deficiencies are probably largely due not to his natural incapacity, but to defects in his early training, and these defects may to a large degree be remedied by proper training in the technical school.

Take the case of spelling, for instance. The evidence that the spelling of the freshman can be im-improved is found in the following quotation from an article by Professor J. S. Clark, Head of the English Department in the Northwestern University, Evanston, Ill., printed in *The Nation,* November, 1906:

"We have uniformly given, in the tests, one hundred and fifty words, and have 'passed' all those who have misspelled not more than twenty out of the 150. Yet, although great pains were taken to pronounce every word distinctly, and to define it both directly and by giving a sentence containing it, nearly 60 per cent. of the freshmen, on an average, have failed to pass the test from year to year. For many years we have required all who have thus failed to enter a sub-freshman class, one hour a week, and to continue there until they either materially improved their spelling or demonstrated to us that they positively could not learn to spell. The work of this sub-freshman class, significantly dubbed by our students 'the pity-sakes class,' has, of course, not counted among the required number of hours in the college curriculum. Although most of the young people who have gravitated into this class have been vehement in declaring that they positively never could learn to spell,

we have found, from year to year, less than one per cent. of incorrigibly bad spellers among them. We have not pretended to perform miracles, or to render carefully observant, during the rest of their lives, young people who came to us habitually careless and non-observant. But we have found that a very few hours of drill have been sufficient to cause practically all of the members of each successive class to pass readily tests quite as severe as those in which they failed on entering college. . . . Nearly all the improvement that we have been able to secure in the spelling of our students in this sub-freshman class has been obtained simply by requiring them to spell syllables analytically. In other words, we have insisted that they learn to observe carefully the successive construction of polysyllables.

"After this somewhat wide experience and observation, I am convinced that much of the talk about the difficulty of learning to spell English is not founded on fact. I am also convinced that most of the bad orthography exhibited by our secondary school graduates is due to the unwise, unscientific, and unpsychological method of teaching orthography to young pupils in our grammar and high schools, generally known as 'the word method.' Invaluable as this method is in teaching the young child to read, it certainly teaches him *not* to spell."

The young student's deficiencies in arithmetic may easily be corrected by making him practise some arithmetical work in connection with mathematical problems of the freshman and sophomore years. His failure to use his eyes in observing the things around

him may be remedied in the English department by giving him compositions to write which will cultivate his observing powers; and in the department of drawing by selecting things for him to sketch which will compel him to observe the details closely.

Another trouble with the young freshman is a kind of bashfulness which makes him afraid to show his ignorance by asking questions. This trouble may be remedied by the individual instructor encouraging the asking of questions by the students at the proper time. The tutoring system, in which each student has a preceptor who assists him in all of his studies, which system has lately been introduced in Princeton, should also prove an excellent remedy.

By the methods thus outlined, it is possible to train many poor students into good ones during the freshman year and thus prepare them for the professional training that is to follow.

The next part of the problem is the pedagogic methods to be used in teaching the mathematical and other courses of the first two years. Mathematics, physics, chemistry, elementary mechanics, descriptive geometry, drawing, kinematics, shopwork, etc., should be taught not as cultural studies, nor as ends in themselves, but entirely with a view to their being made use of as the tools of the engineer. The heads of the several engineering departments and the instructors of junior and senior students should be encouraged to write down from time to time on cards which may be filed, the problems in these elementary subjects which may come up in connection with their work and which the junior and senior students seem to lack the

correct method of solving. These should be handed down to the instructor of the lower classes to be used as occasion may arise for the purpose of giving the students in the elementary branches some idea of how these elementary problems are needed in the engineering courses of the last two years of the college and in engineering practice. Fundamental questions in the different branches of engineering, the answers to which are found in physics, mechanics or chemistry, should be handed down from the heads of the engineering departments to the professors of these elementary subjects. I had an instance in which this was done with good effect two or three years ago. The Professor of Electrical Engineering claimed that the junior students who were just entering upon the subject showed a lamentable lack of knowledge of the fundamentals of electricity, which they were supposed to have studied in the department of physics in their sophomore year. I asked him to write out a list of twenty questions in electrical physics, which should practically cover about all of the subject that the student really required to know upon entering the junior class, and on which if he had had proper training in his sophomore year he should be able to pass examination with a mark of 100 per cent. He prepared such a list and I handed it to the professor of physics, who expressed his delight at receiving it, and asked if I would not have a similar set of questions prepared on the subject of heat. The sophomore students since that time have been drilled in the solution of these questions and there has been no further complaint as to their imperfect preparation in physics.

In the subject of drawing, I found a good problem is to set the man at making first a sketch, then a working drawing of a rather complicated system of water or steam piping in a small power plant, showing the location of pumps, feed water heater, condenser, etc., and after the drawing is finished in ordinary projection, ask another student to make from the drawings an isometric projection of it. This shows up the defects in the first drawing, and sketches, and is a fine training in making the men use their eyes in observing details.

In regard to pedagogic methods in the class room in the regular engineering courses, I believe oral lectures should be given only for the purpose of interesting and entertaining the students, just as one would lecture to a general audience, but that they should not be allowed to take the place of rigid text-book and problem work. If a teacher goes to the trouble of carefully preparing and writing out a lecture and then reads it to the students, asking them to take notes upon it and then write out their notes and bring them in for inspection, a method which still seems to be the practice of some professors, it may be taken as certain that three-fourths of the class will gain scarcely any knowledge from such a lecture. Their mental energies during the lecture period will be devoted to getting down the notes and not to comprehending what the lecturer is saying; and in transcribing the notes, the student's whole effort is to get the words on paper without any care as to whether any ideas on the subject get into his brain. If such a lecture is to be delivered for any

reason, there should be only one note-taker, a stenographer, who should afterwards make mimeographed copies of the lecture to be handed to each student. In general, it may be said that any lecture worth delivering at all is worth being duplicated by the mimeograph process, and then after it has been thoroughly revised, and possibly used for two or three years, it should be printed in pamphlet form, and finally, if it is the best possible statement of the subject, it should be bound in a book. A systematic course of study should have a textbook, and if there is no satisfactory textbook in existence in the professor's opinion, then he should make one. The course of study should also have numerous problems to be worked out arithmetically, or on a drawing board, or both. When a good problem is found which exercises strongly the thinking powers of the students, it should be printed and subsequent classes should be drilled on it. When possible, a series of problems all involving the same operations but with different numerical data should be used, so that each student gets a separate problem. The results may then be tabulated and errors in the solutions easily pointed out. I have found a good series of problems in elementary steam-engine work to be the following:

"Required the mean effective pressure, the horse-power, and the probable steam-consumption of a single-cylinder engine under the following conditions: area of piston, 100 sq. in.; piston speed, 600 ft. a minute; steam pressure, 80, 100, 120, 140 and 160 pounds; cut-off, 0.15, 0.20, 0.25, 0.30, 0.40, 0.50, 0.75 of the stroke; back pressure, 3 pounds and 17 pounds

absolute; compression in the non-condensing engine to one-half of the initial pressure; in the condensing engine, compression begins at 0.6 of the return stroke; clearance, 2, 5 and 10 per cent.; cylinder condensation considered as a percentage of the length of the stroke, 6, 7, 8, 9, 10, according to the initial pressure." This series gives $5 \times 7 \times 2 \times 3 = 210$ separate problems, enough to give five or six to each member of a large class. When this set of problems was sprung on the students and they were asked to bring in after several days the complete solutions, it was found that the results which ought to plot in a series of smooth curves had no relation to any curves whatever, the errors being due to all sorts of mistakes in arithmetic. When these mistakes were corrected, a fine lot of curves resulted and they showed clearly the relation of probable economy to cut off, to clearance and to pressure.

The above remarks are offered merely as an introduction to the general subject of pedagogic methods and for the purpose of bringing out discussion on the definite question, "What is the best pedagogic method in each engineering course?" I submit that the best method will not be arrived at by mere discussion, but by actual experiment and the systematic recording of the results of such an experiment. One trouble with the subject now is that it has so many variables and that there is no satisfactory standard of measurement for any of the variables. I hope these remarks may lead some of our professors to make some experiments and to bring us the results in some such form as the results of the spelling class in Northwestern University, which I have quoted above.

JOINT DISCUSSION.

DEAN WOODWARD: Professor Raymond said that he himself, in order to understand better the method of the individual instruction, took two of the subjects personally. I would like to ask if he also took two of the same subjects of the other section of the class so that his intellectuality and force of character would equally impress the two sections. Were the teachers equally competent, equally enthusiastic, equally hard at work? These are very important matters to consider before we can make anything like a comparison of results. If in individual instructions elaborate lectures were dispensed with, that would be a clear gain.

DEAN RAYMOND: I taught this section algebra and surveying, and I did not teach any other section algebra, but I have taught other sections in surveying. The instructor in mathematics, who covered the trigonometry and analytical geometry, is rated as one of our best instructors in mathematics. The instructor in drawing and descriptive geometry had also part of the rest of the freshman class. Owing to some irregularities in hours, I think the disadvantage of instruction was generally with this special section.

PROFESSOR WILLISTON: I would like to ask whether in this plan of individual instruction but one subject was studied at a time, or whether two or more subjects were studied at the same time, and if so, what was the maximum number of subjects studied during any one week?

DEAN RAYMOND: The maximum number was three. I would prefer to have two. Part of the year it was

but two. When a student is studying a subject that is studied partly by text and partly by laboratory work, I would have but two, this one subject and English. The chemistry text was studied in the morning and the laboratory work done in the afternoon.

The Chair: Were these two subjects under the direction of two different instructors?

Dean Raymond: Yes.

The Chair: So you could have the student carry on the two subjects at a time with two instructors?

Professor Williston: In an earlier presentation of Professor Raymond's plan, I understood that it was his idea to have the student take up the subjects in an engineering course one at a time, finishing one before he was allowed to begin another. To follow that plan consistently would, I believe, lead to serious difficulties, and I am glad to know that Professor Raymond has not attempted it. I think, however, that he has made a very great gain by reducing the number of subjects which are usually carried at one time by engineering students. His arrangement limits the number of subjects on the program at any one time to three. I believe that there would be immeasurable gain if all engineering schools could approach the same limit.

I think that there is also an important advantage in Professor Raymond's plan which comes from frankly recognizing the fact that no two individuals are alike, and that no two men have the same capacities. I believe that we should attempt to meet the individual needs of our students, although I do not

believe that it is absolutely necessary to have them taught entirely by the individual method in order to accomplish this. It is, however, necessary, in order to get the most efficient results, to recognize in one way or another the fact that the training and experience of different men before they enter college is apt to be very different. Their capacities are different, their tastes differ, and equally capable men grow and develop at different rates and in different ways. Enough individual attention and instruction therefore should always be given to allow for these differences of personality. In many places at the present time, I believe, too little attention is given to these, and the assumption is too often made that all students should acquire the same intelligence and information in the same time.

One more point I want to commend in Professor Raymond's plan. He has endeavored to make the atmosphere which surrounds the school work just as far as possible exactly like the atmosphere which his men will later find in practical work. The sooner young men become accustomed to the kind of requirements that will be made of them in real life the better; and in so far as the plan described in this paper accomplishes this result, there is real gain.

Professor Higbee: I taught a section in descriptive geometry in the regular way. I am confident that there were men in the special section who would have failed had they taken the subject in the regular way. And I am confident that there were men in the regular section who failed because they were in that section. They spent so long getting the elements of

descriptive geometry that the class got ahead of them. I wish to disagree with Dean Raymond. I think the work of teaching the special section is much harder. I could attempt to teach two regular sections, but I would not attempt to teach two special sections.

THE CHAIR: Why do you consider some of the men would have failed who were in the regular section had they been in the experimental section, and vice versa?

PROFESSOR HIGBEE: One man in the special section spent a very long time getting a hold of the very elemental principles in descriptive geometry. He had great difficulty. But when he had mastered those two or three problems, he went right ahead. Some men in the regular section spent so long getting a hold of two or three elemental problems that by the time they had mastered them, the classes were very far ahead and they could not catch up. But in the special section a man had no opportunity to get behind. You know if you master two or three elemental principles in descriptive geometry the rest is easy.

PROFESSOR F. C. CALDWELL: It has always seemed to me that this individual system was the ideal toward which education should get as close as possible. This is one of the great advantages that the laboratory has over the class room. It is a financial question, too; how near can we come to this system with the money available? I should be glad if Professor Raymond would give us some information regarding the comparative cost as compared with the ordinary system in use.

DEAN TURNEAURE: I am in hearty sympathy with

this work. I believe that in a subject like descriptive geometry the individual method can be very effectually applied, as there are many students who cannot readily master the elements of this subject without such aid. But individual instruction is something which we all attempt to secure as far as practical, and do secure to a large extent in the laboratory, in the drafting room and in the field. And here is where we get close to the student, become acquainted with him and get his point of view; and as a consequence it is here where some of our best work is done.

Professor Chatburn: Through my past reading I have been very much interested in Professor Raymond's scheme of individual instruction, but do not think it practicable for all subjects. In our work in descriptive geometry and machine design we do apply it. In testing materials I cannot use it because, even if I thought it feasible, I have not a sufficient number of machines, and therefore find it necessary to group the students, but sometimes the groups are larger than I like.

Something of this character has been attempted in the Lincoln High School. The head teacher of mathematics has evolved a scheme whereby all students are required to work out a certain number of problems which they do individually but in sight, and under the direction of one of the teachers, two hours a day being given to this work. It seems to be a success, but I question whether students from this school come to us better prepared to take up the subject of mechanics than do students from other schools where individual instruction is not in vogue.

I would like to ask Professor Raymond how he would teach surveying with economical results? If "engineering is the science of economics" we should study to teach in the most economical manner. Out west we must do that, as we have not money to do otherwise.

Since the other paper is also under discussion I would like to say with reference to spelling—that spelling has always been my *bête noire,* it is the hardest thing I have ever had to deal with. I do believe, however, that good spelling is a matter of observation, that a man who is a close observer of details will be a good speller. This might be illustrated by such words as "accessible" and "capable." The last parts of these words are usually pronounced alike, but spelled differently. Spelling is a matter of observation. Are we poorer spellers now than they were formerly?

VOICES: Yes, yes.

PROFESSOR CHATBURN: Some one has recently dug up in Massachusetts an old spelling list of half a century ago with records of an examination from this list. The same list of words was given to the pupils of a school in Springfield, and I believe the results were in favor of the latter as against the former pupils although the modern pupils were of lower grade. I believe the present generation to be on the average as good spellers as were those who lived fifty years ago.

DEAN KENT: Spelling is not an inherited gift. It is something to be acquired, and the way to acquire it is the old-fashioned way of studying the syllables

in the word. When this is done bad spellers can be turned into good spellers. As to the matter of individual teaching I am heartily in sympathy with the author. For a poor student it is better to teach him individually, but for most cases class-work is good enough. In Princeton they preserve the class method, but put each student in charge of a tutor who will help him along. Another way of getting individual work is to tell the slow student that he must study more than the others, and to give him encouragement to work hard by saying, "If you get such and such marks we will not give you this extra work." In regard to no two students being alike, I think a good many are alike. I would not say that in a class of fifty there were fifty different kinds. I would say there were four different kinds. First, there are the "A" men, mentally quick and industrious; second, there are about five per cent. who are quick mentally but are lazy, or do too much outside work, or are engaged in too much frivolity, football or something. They do not put in enough hours. The third class is mentally slow but industrious. They do not accomplish as much as the first class, but may do more than the second. The fourth class are also slow, and in addition do not put in enough hours; it is pure laziness or too much outside work and fraternities with them. It is those who are mentally slow that must have their minds stimulated, and they must be looked after to see that they put in enough hours. It seems to me the Princeton method is a good one.

A VOICE: Send that class home.

PROFESSOR MAGRUDER: I would like to divide the

men into three groups instead of four. I believe Professor Raymond's method would be excellent for those who are uncommonly bright and for those who are unusually slow. For the average man, the class method is the better. The slow man may require five or six years to complete one of our engineering courses, but he may be the man whom we want in the average position in our works. Then we have the quick man, who like one of my instructors prepared for Yale by doing his high-school work in two and a half year's study and got through the college course in three years. Why make a man like that stay the fourth year, to be pulled back by the drags?

I believe it would be a wise experiment to make if Dean Raymond would divide the frehman class into three sections; put into one section the men who are abnormally slow, into the other section the men who are abnormally bright, and into the third section the men who are normal.

The examples to which Dean Kent refers are not at all uncommon. A large stock of such examples whose variables vary greatly are desirable in the instruction of large classes.

PROFESSOR WILLISTON: I would like to suggest that different men will not rank the same in all subjects. The man who is especially bright in one subject may be slow in another, and perhaps has average ability in a third. It would, therefore, be impossible to divide a class in all subjects according to Professor Magruder's suggestion. One man has good imagination and little power of observation; another is an accurate observer, but without imagination. The same

differences apply in a dozen other faculties, and one may find in any large class as many different types of minds as there were different kinds of problems in this interesting paper.

The difficulty of separating the men of exceptional ability from the men with average ability, or little ability, was well illustrated by an incident just referred to. The student who found it so extremely difficult to get into his head the first notions of descriptive geometry, took several times as long as the majority of his classmates to complete the first few problems. But, after he had mastered the elementary principles which they contained, he made more rapid progress than almost anyone else in the class. It would surely be impossible to classify him in any satisfactory way except in a class by himself with individual instruction.

President Howe: I have been very much interested in this paper because for years we have used the individual method in descriptive geometry. Sixteen years ago I tried to use the individual method in teaching freshmen mathematics. I could not use it more than one year for lack of time. This was done especially in work on problems. It was very satisfactory as far as it went. Educators have been thinking of this matter for many years. Public school men have been trying to take care of the boy who is behind, and they have solved it in many schools by putting in additional teachers so that enough instruction can be given to the backward boy. Princeton has tried to solve this matter by its tutorial system, because many students fall out of the classes each year. It all in-

dicates that we are not satisfied at all either in the public school work or the college work or the technical school work with what we are doing for these students. We have not reached the end of the subject yet. I have thought about this a great deal. It hurts me to see men drop out of the freshman class when I think they ought to be able to go on. I don't think our system is so poor that we ought to revolutionize it entirely. Neither do I think it is necessary; but we ought to change our methods so that twenty to forty per cent. of men will not drop out of college. It is not a question of keeping poor students. If a man shows that he is not adapted to college work, the thing to do is to let him go. Many of us can recall the man who just scraped through college, and made a most brilliant career after he got through either as a successful engineer or a successful business man along engineering lines. We are dropping men who possess these qualifications, and if we can devise means to keep them in college, they will not only become ornaments of the college, but successful practitioners. I hope we shall get a more perfect system of teaching in our technical schools.

Professor Webb: The student that was so long in getting started in descriptive geometry interests me. Of course the object in giving him special instruction was to discover and remove his peculiar difficulties and it would seem that by trying different methods and instructors a week or two might have sufficed—or else he must have been a Scotchman and needed a surgical operation. Professor Kent reminds me of an incident, which occurred while I was studying in

Germany, and Professor Eddy will remember the semester when we both took Professor Kirchhoff's course in analytical mechanics. The course occupied four semesters and Professor Kirchhoff was asked to print it. When the first volume appeared, the students brought it to the lecture room and instead of listening with wrapt attention to the professor's elegant demonstration they kept but half an eye on him to see that he followed the book. This so annoyed his sensitive nature that only the first volume appeared. As to the difficulty of listening to a lecture and taking notes at the same time, it was more than I could well do but with the German students it was the customary thing, they didn't attempt to write all that was said but made abstracts which I referred to on difficult points and found to be excellent. The acquirement of this art by our students would place them in a higher grade, but of course the easiest and surest way to put them in possession of the knowledge necessary for a degree is to have the professor put all he knows, and more, into textbooks and make the students buy them.

PROFESSOR EMORY: It occurs to me we might divide the students into two classes, those who come and those who are sent. As to Professor Kent's paper the point which appeals to me has not been mentioned. It is the necessity of teaching accuracy, even in the simplest problem.

PROFESSOR BOYD: One thing about classroom work has not been mentioned, and it is one of the most valuable. It was where I had to recite to a class. If you are teaching one individual student,

then many things may be omitted. But if you are teaching a class, they ask questions and all these things are brought out. I learn more from questions by students than from anything else. I think class instruction is a good thing for that reason.

Professor White: A method of conducting class exercises has been developed in the mechanical engineering department at the University of Illinois which has proved to be very efficient and also a great time-saver both for the instructor in preparing his work and for the students at the beginning of every recitation period. At least as many problems are worked out for each lesson as there are students in the class and these are revised from year to year with the assistance of other instructors. Each problem is written on a standard card and may require the drawing of a diagram or the working out of a solution on the blackboard. The cards applicable to the lesson of the day can be given out rapidly at the opening of the period and no time is lost. A similar plan can be followed for quiz questions, and if in addition the class roll is kept on cards which are frequently shuffled and the student called whose name is on top, a much livelier interest will be maintained in recitations than is the case when a student knows about when he will be called and about what part of the lesson his question will be on.

Professor Jacoby: I also prepare questions beforehand on cards, for another reason. It not only saves time, but the questions being read by students helps to maintain a higher degree of interest in the class than if all the questions were asked orally by the

teacher. In some of my class work it has been productive of very good results.

PROFESSOR CONSTANT: The discussion has shown the necessity of considering the subject in determining the applicability of the individual method. It has been brought out that the method is practicable, perhaps advisable in the laboratory and for such subjects as descriptive geometry, where the work is cut out and the student knows what ground is to be covered. In the higher classes I suppose the practice of the majority of instructors is exactly this individual method. The students are given problems to work out and designs to complete. A student proceeds to do his work individually under the eye of the instructor. I believe there are two objections to the method in this kind of work. One is the lack of economy in instruction. The tendency is for each student to ask, and of course, at different times identically the same question and the instructor soon gets tired of elaborately explaining the same thing to practically every member of the class. After a question has been asked two or three times, I gather the whole class together and explain that point once for all. If a man comes two or three weeks after the class has passed that point and asks the question I have answered so many times before, I find that I have grown stale in the subject and it is difficult to answer him with any degree of enthusiasm.

But the principal objection to the individual method is the lack of the spur which combined class effort creates, and the resultant loss of ground that ought to be covered because of the student's inability to

make rapid progress in a new and strange field when left to his own initiative. I am considering withdrawing a good deal of the design work from the drawing room, and carrying on the work in the classroom. Representative problems to illustrate each new principle can be presented quite as easily, which will be worked out by the class at the blackboard. These may be supplemented by home exercises and a small, judicious amount of drawing room work which will bring out all of the elements and principles of design. Of course the present so-called complete design will not be possible by this method, but I am convinced that the principal value of the complete design is in producing something which the student may show to his parents or friends to demonstrate what a learned and skilled young man he is, or that the professor may with like pride exhibit to visitors to demonstrate the practical scope of his instruction. The complete design represents much wasted effort, involving as it does much reiteration and mechanical execution without a corresponding amount of new theory and real educative matter, while the very effort of making it complete by including at the last all the little finishing strokes which come so easily with experience and so hard to the novice, involves a great loss of time on the part of the unskilled student that might much better be spent in acquiring new principles and broader ideas. I think much more ground can be covered by the classroom method than by the slower individual method and I hope for very much better results. So far as design work is concerned I believe that the individual method is not wholly a success.

Mr. Leete: We make an approach to this method at the Carnegie Technical Schools in the School of Applied Science. We divide the class into groups of twenty men, making their preparation in mathematics the basis of division. The section which was best in mathematics also did the best work in other subjects, so that they could be handled almost as a unit by the instructors in the different departments. This, of course, does not accomplish all the results aimed at by the method of individual instruction, but it does prevent the serious difficulty of teaching students of such wide disparity in preparation and in ability as are ordinarily contained in groups in which some scholarship basis is not used in making the division. It has, however, the distinct advantage of pitting mind against mind, which individual instruction does not permit. I have sometimes thought, however, that it is rather hard on the poor sections, as it possibly takes away some incentive for work.

We accomplish something of the same result in the upper classes by exercising some supervision over the students in the choice of course, so that the student is required to show during his first year of general work some special aptitude fundamental to the course which he is to elect. This is, of course, only an approach to the method of which trial has been made by Professor Raymond, but I think it may be said to be along the same general line.

Mr. Wiley: The teachers of the ancient classics used to grade their freshman classes, thirty years ago, according to the ability of the students. We took up the study of Homer's Odyssey. The first

few weeks we were all graded alphabetically. After that the sifting process commenced, and the smart students were grouped in the first section and to them was given the option to go further; and it was surprising how many would do that work willingly. I think the same system was in progress in the Lowell Institute.

Professor Webb: I have heard many times of these students that never do anything worth mentioning in college, but are allowed to graduate, because some such student once made his mark in the world afterward. It has always been a question with me whether he would not have made two marks if he had not been to college at all.

Dean Eddy: There is something to be said in favor of this dual division. It reminds me of the chauffeur who divided the whole human race into two classes—the quick and the dead. There is a practical difficulty in the grading of students according to ability into divisions first, second, and third; it is particularly hard on the man that teaches the last division, for the snap and energy of the able student is taken away from it. It is almost impossible to teach a class of men who have been merely sent to college and so are likely to be without any particular initiative of their own. We seem to imagine too that students are taught by their instructors, whereas a very great deal of effect is accomplished—and perhaps more than we imagine—by the students themselves upon each other. The result of any educational institution is largely the effect of the students upon each other, rather than the effect of the professors upon the student. In-

deed our profession is surrounded in our instruction by innumerable unknown factors. We are glad we have all these factors submitted to experiment and trial as has been done by Dean Raymond, and thus we seek for still further modifications of our methods of instruction in order that we may accomplish results more satisfactory than those that have been reached in times past. No two instructors, however, can accomplish precisely the same results by the same methods. Minds do not work in the same manner in attempting to impart instruction, and the results accomplished upon students by instructors are not the same with two successive classes. It is an exceedingly indefinite problem which from our younger years to our older years we are attempting to solve, and it is our task to accomplish it amid all these varying modifications and reach a result which shall be satisfactory.

Professor D. C. Jackson: [The Secretary in the chair.] This discussion has opened out into a discussion of the fundamental difficulties that every good engineering school is making an effort to overcome. There are a number of points in which I cannot agree with the opinions expressed. There do seem to be characteristic similarities in students, as has been said here; but they change so much in one's hands that it is almost impossible to classify them. A student who belongs in one division this year does not belong there next year. The first-year newcomers are often quite calf-like,—are still in the milk, as it were—but, across the room, the sophomores who have had one year of experience knocking around with their fellows are

quite human-like. That is characteristic of the change that occurs every year throughout a man's college life, and it occurs every month if they study properly. Hence it is very difficult to sub-divide the classes on the ground of accomplishments, and do fairly by the men. Perhaps we would be willing to sacrifice one man provided we could do a great deal of good thereby to the many others, but that is not always possible. The men are made up of a complex of numerous elements which gives dissimilarity. But the elements are or may be combined in such innumerable ways that it is impossible to classify them properly and to separate the good from the bad, the quick from the slow, etc., and do it effectively so that the separation will stay put as a separation of the good from the poor. If one is going to make a separation it must be a separation with a diaphragm which is permeable, and the units must be going from one to the other constantly, or the arrangement is not good pedagogy.

I don't agree with President Howe that it is a mistake to drop a man from the engineering college. It hurts my feelings, it touches my heart, because some of the men are very loath to go, and are earnest in their work. But if we are careful of our method of dropping men, and select the right men to drop, it is to their advantage, because they are the men *who are steadily falling farther behind.* They are the kind that would be dropped from the medium to the slow class, and then be dropped out finally if we attempted to make the separation in that manner. Such students will never become proficient men and it is unwise for

them to spend the great length of four years of their youth in the engineering school. I have been able to see but few of what I will call the "slow" men in college make their mark after they leave college. On the other hand, to my mind the "slow" man is not necessarily the man with poor marks as compared with the man with high marks. The slow man is the man who fails to get a grasp of the subject and to come up with a good sensible knowledge of what he is studying and the relations of the things he is studying about. If a student gets a good grasp of his subject by obtaining a good sensible knowledge of the subject and the relations of the things about which he is studying, I do not care whether he has low or high marks in college, he will make a good mark when he gets in the world. Whereas, even if he has a good record as far as marks are concerned, but does not correlate his work, that man is a poor man, and ought, perhaps, to be dropped. Once in awhile, also we come in contact with a student who is so awfully slow that he is thick-headed and ought to be dropped.

Taking my experience of sixteen years, there have been a few men graduated from the course that I have been responsible for during that time that it has hurt my feelings to graduate, because I knew they would never make high-grade, professional men. They were just enough above the line in respect to marks so that we could not drop them out with abstract justice counted from the standpoint of college marks. I don't remember a single man of that kind who has made a professional mark. Lots of them are sub-superintendents and doing all that their ambition will lead them

to do. But the prime point is that they would be just as far along in their business career, and perhaps a little farther, if they had gone away from the engineering school one year earlier. The last year was too high for them. They could not correlate it with their work and it might have been to their advantage had they been dropped at the end of their junior year. But on the other hand, a lot of fellows who had done very poorly in the lower years did so well in the upper two years, and especially in the senior year, that we were glad to allow them to graduate. And a good many of these have made professional marks.

The point that I wish to make is, that we have to judge the students from the standpoint of *the way in which they are assimilating,* and not from the way they get marks. Therefore Professor Raymond's method has some good features. But he goes too far, according to my point of view. I quite agree with Professor Williston that the engineering schools have attempted to teach too many subjects to the students at once. I believe that two subjects treated in a single day are sufficient, but I believe that four to six subjects carried along in parallel are preferable to two, and that the four to six will bring better results. But when it comes to ten or thirteen different subjects, as will be found in the catalogs and in the actual work in some engineering schools, it may be said with perfect fairness that that is wrong and must be reformed.

Now, in respect to the treatment of the subjects: I cannot agree with Professor Raymond that the lecture is not desirable; I cannot agree with Mr. Jones that

the textbook is not a good thing. I am a textbook writer. But I say this: In respect to the lower classes, I cannot speak from personal experience, I will have to leave that to others. I speak according to my observation and judgment, but I will confine my consideration to the upper classes. In respect to the upper classes in engineering in which the work is directed immediately toward professional lines, it seems to me that by providing a certain number of lectures in each important subject—one or two a week, which expand the textbook—go beyond it—to accompany classroom recitations and laboratory work, and plenty of problems, one gets the best results. And the further a student has progressed in the college course, the more the student should be put on his own responsibility. When it comes to the fifth year (that is, to a graduate year) the student ought to have a very full responsibility as to how he studies and what he studies. Now there is not only the advantage of bringing the stimulating influence and interest which is brought through the proper lectures that illustrate the textbook, but there is a gain in a characteristic type of concentration which one does not gain through the use of textbooks. A man should learn not only to take a view through his eye from the textbook, but also through his ear. We do not want men to take extended notes from the lectures. We want them to listen. If they do not listen constantly and well they have lost one of the great gains of the lectures, which is ability to grasp a man's sentiments through the ear. This is a very important accomplishment for every engineer who expects to make himself notable.

As far as financial matters are concerned, it is about as expensive to teach engineering one way as the other, whether by lecture, or textbook, or the laboratory method. So our friends who have not yet come to the point where they feel that they have the financial strength to try the individual method must simply look forward to getting more money anyhow. It is the great pull. The money must be had.

The difficulties that Professor Kent has been struggling with will be quelled by his seeing to it that the departments all play fair and pull to one end, and that every department helps the other departments,—that the chemistry and the physics and the mathematics and the language departments come into the game with just as much vigor and just as much push toward the desired end as the professional departments. That is one of the objects of a dean at the head of an engineering school connected with a great university. We find that it is the dean's big work; and in that way he makes the strength of the engineering school. I have not been a dean, but I have looked on, and I am convinced that my diagnosis is right.

Professor A. N. Talbot: The discussions to-day follow very closely the same lines of those of five and six years ago and which may be found in the volumes of the society's proceedings, though it seems that Professor Raymond has modified his position somewhat. Two points have not been brought out very fully in the discussion to-day, which it seems to me should be emphasized: first, the average student gets a great deal of value from contact with other students in the class room, which it would be

a great loss not to have and which he may not get in any other way; and second, as it seems to me, it is not good pedagogic practice to teach the immature student only one subject at a time or even two at a time.

Dean Raymond: You have so successfully closed the discussion for me, better than I could have done myself, that I think I shall only answer one or two questions. In my first paper on this subject I stated distinctly that not all of the subjects could be taught individually. I said that surveying could not be taught individually. It takes more than one man to perform the field operations, and there are other like subjects. Chemistry and physics must be taught partly by lecture—perhaps less by lectures than is now customary, but partly by lectures. President Howe asked for what purpose we made these experiments. Six years ago I had the honor of presenting this subject to the Society for the first time, and the discussion at that time was carried over into the next year, and my recollection is that there was not a single favorable voice.

The Chair: I was against you.

Dean Raymond: Yes, decidedly. One reason for carrying out the experiment was to see whether what has apparently been done could be done. Judging from the discussion to-day our President has come part way, and he and the rest of you will come all of the way.

Dean Kent: I agree with the chairman in regard to some lectures, especially such lectures as he would give. But some lectures are dry and tedious. When

I was a student thirty years ago I took lectures and all my energy was spent getting down the notes, and then all my attention was devoted to the mechanical work of transcribing the notes. And when I looked at the lecture, weeks afterward, it was entirely new to me. I would have to read it over again to pass examination. That is the reason I have been strongly set against that kind of lectures. But I am in favor of the lecture for instructing on some matter of practice, which is the same as a lecture for a popular audience, and of which no notes are taken. But that does not qualify an engineer. It is a good thing to add to the course, but it is not the course. It is the problem that a man works out himself that is the real work. That brings results.

Professor Mabery: I have been interested in the general discussion, especially what relates to the individual method of instruction as compared with class instruction. I have often thought that the element of time in education as a feature of mental expansion is of considerable consequence. Nature moves slowly and steadily whether in the development of physical or mental force. It would seem that a broader grasp of a subject may be gained by devoting to it say three hours a week for six months or a year than can be accomplished by completing it in one-third or one-quarter of this time in daily exercises. I believe this to be the fundamental value of college and university training. A student occupied twelve hours a week has leisure to assimilate much that is not in the books. It is much the same in scientific training. A subject carried through the year in regular periods imparts

better training than the cram incident to condensing the subject into three or six months.

The student who gives all his attention to one subject becomes a grind. A change from one subject to another is restful. It is better to carry along several subjects together. As has been suggested the student gains much in the general intercourse of classroom work, just as in such meetings as this, ideas are brought out by discussion and criticism.

With a class of 150 or more students there is no other method of presenting satisfactorily elementary chemistry than by lectures. A student can learn chemistry only in the laboratory with a sufficient number of teachers for individual instruction.

I believe in this combination of the lecture method and the individual method; presentation of the subject by lectures, individual teaching in the laboratory, and class revision by recitation and tests.

RELATIVE EFFICIENCY OF INSTRUCTION IN ENGINEERING SUBJECTS.

BY JAMES M. WHITE,
Dean of the College of Engineering, University of Illinois.

This paper presents the results of an attempt to reduce the work of instruction in widely different subjects to a common basis for the purpose of comparing the economic efficiency of instruction in the several departments of the College of Engineering of the University of Illinois.

In recitation subjects, the number of hours spent in the class room is the criterion of the work of an instructor, but the same number of hours spent in the drawing room or shop would not represent as much work because there are not so many problems and quizzes to correct outside of class hours; neither does summing the measures of the amount of work required of the students in the courses taught by an instructor give a fair comparison of the teaching work involved, because in laboratory and shop courses, for example, the instructor must be present all the time, which corresponds to both the recitation and the study period in other subjects.

The size of section and the method of instruction must also be considered, because with proper system an instructor can teach twice as many students as efficiently in some subjects as in others.

As a measure of student work the semester-hour is used here and means the number of one-hour class

exercises per week, each requiring two hours' preparation, or the number of three-hour periods in subjects not requiring outside work.

The values in the first two columns of the table given below are the consensus of opinion of forty members of our Engineering College Faculty, and I believe they are consistent with our methods of instruction. The first column is the number of students who can be taught as efficiently in the several different classes of work as twenty-five can be in a recitation exercise. The second column gives the number of semester-hours of teaching in each of the several subjects which will require the same amount of the instructor's time as would be required for fifteen recitations.

For the purpose of this investigation it does not make much difference whether or not fifteen sections of twenty-five students should be considered fair work for an instructor, but it is essential that the other values represent relatively the same efficiency of instruction and the same amount of the teacher's time.

Column three is the product of one and two and column four is the ratio of all the other values to the first one. In the last column the equalizing factors are given in round numbers. The values for lectures have been divided by two because the values in the first two columns are based on experimental lectures which would require the services of an assistant.

The factors are used as follows: The number of students in each course multiplied by the number

of semester-hours of the course and by the corresponding factor gives the amount of instruction involved, reduced to the basis of recitation work.

Column	1	2	3	4	5
Recitation	25	15	375	1.00	1.0
Lecture	150	5	750	2.00	1.0
Drawing	30	9	270	1.39	1.4
Designing	18	9	162	2.33	2.3
Shop	18	12	216	1.74	1.8
Laboratory	12	9	108	3.47	3.5
Field-work	20	10	200	1.87	2.0

The total equivalent work of all departments can be computed in this way. These values divided by the number of instructors should give approximately equal values if the teaching staff is properly balanced, provided there are enough students in all cases to make economical sections.

An interesting comparison may be made by dividing the salary list of each department by the total equivalent work of the department to obtain the comparative cost of instruction in each.

The factors may also be used to determine the number of instructors that should be provided to teach a subject to a given number of students a certain number of times per week.

Discussion.

Professor Wood: Do the times given include the time for necessary preparation of the machines and apparatus for testing?

Dean White: Not in any way. I believe the students should do the bulk of the work of setting up the apparatus, but we have a mechanic in each labo-

ratory who assists, and very little of the actual work devolves upon the instructor.

PROFESSOR WILLISTON: I think that this list calls our attention rather forcibly to the difference that there is in the practice of different schools. In the University of Illinois the practice apparently is to devote very much more time to the preparation of lectures than to the preparation of other kinds of work; next is the preparation for recitations. The same amount of time is devoted to the preparation for drawing-room exercises, for designing and for laboratory work. No preparation is required for shop-work. Instructors in the latter subjects therefore can carry a larger number of instruction hours on their schedules than instructors in other subjects.

At Pratt Institute, for example, the conditions would be very different. There the men who are handling large classes in the machine-shops, the foundry, the forge-shop, or the pattern-shop, are able to carry fewer instruction hours per week than the men who have recitations in mathematics, physics or applied mechanics. The majority of the latter instructors are assigned from eighteen to twenty hours of recitation per week, while the average for the shop instructors would be from sixteen to eighteen hours per week actually spent with classes, the balance of their time being spent in preparation.

DEAN RAYMOND: Did I understand Dean White to say that he wished these figures to be taken as relative figures and not as indicating his opinion of the number of students that can be taught in a class?

DEAN WHITE: The first column gives the number of

students in each different class of subjects which in the opinion of our faculty can be as efficiently taught as twenty-five can be in a recitation subject such as algebra or German.

Dean Raymond: Then I suppose a point in the discussion might be one's opinion as to these figures?

Dean White: Yes.

Dean Raymond: I cannot teach efficiently twenty-five students at once in any subject I ever tried. I can lecture to perhaps almost as many men as I can get within the range of my voice. I doubt very much if thirty men could be taught efficiently by one teacher in one drawing period. In field-work I cannot teach twenty men at once and have efficient work done. There ought to be one instructor for every party the size of an ordinary railroad party, say, ten to fourteen. The other work I am not so familiar with, and the figures come nearer to my notion of what might be. But 25 in recitation, 30 in drawing, and 20 in field-work are too many. I think fifteen is a good number for recitation with twenty as the maximum.

Professor A. N. Talbot: These returns are opinions given on the basis of the number which may be handled as efficiently as twenty-five students can be handled in the recitation room. I do not understand that Dean White has given his opinion that twenty-five should be handled in the recitation room. Referring to Professor Williston's remarks, it is to be considered that the course in any one of these subjects has been fully outlined and that all preparation for it, like notes or plans, has been made in advance.

Professor Webb: This discussion as to the best way

to teach large classes has so far been conducted upon the supposition that as the classes become larger the number of teachers can be suitably increased. In my work the problem has taken another form, which may be worth your consideration.

Suppose that a professor has charge of the junior and senior classes in some advanced subjects for which each of them comes to him three times a week, and that he must prepare his lectures, his blackboard and other illustrations and his models, and look over and mark frequent written recitations and problems without any help, besides attending to matters of attendance, order and discipline, examining conditioned students, meeting committees and making frequent reports such as may be expected in any institution conducted on the card-index plan. Suppose that he finds that he can do this efficiently with small classes and that the numbers increase, say from twenty-five to one hundred in each class, so as to impair the efficiency. What is the best thing to do if no help is given him?

If the subject is given by lectures he can in a properly appointed room take the whole class at once, and he can give occasional written recitations and look over the papers afterwards, and do this with a measure of success if all the students are in earnest and he has their attention, and if students who fall behind are dropped back. But he will be overworked and unable to keep up with the literature of his subjects, let alone doing any outside work in them, and he will know that his teaching was better when the classes were small. Now shall he divide the classes

and if so into what size sections? If he tries them in sections of twenty-five each he must spend twenty-four hours per week in the classroom and find most of his energy gone when he escapes from it, but he will have as many recitations and problems to look over as ever, besides which extra time will be needed in preparing his lectures so as to keep the different sections together and be sure that the same explanations are given to all the sections. It will therefore be impossible to teach them in four sections each and the question is can he expend his stock of energy most efficiently upon the class as a whole or would it be better to divide it into say two sections? Or to put it mathematically as a question of maxima and minima, given a large number N of students, and a fixed amount E of teaching energy, per week, each student to spend H hours weekly in the classroom, required the number n of sections for the best result.

THE NEW ELECTRICAL ENGINEERING BUILDING AT THE WORCESTER POLYTECHNIC INSTITUTE.

BY HAROLD B. SMITH,
Director of the Electrical Engineering Department,

AND BY ARTHUR W. FRENCH,
Director of the Civil Engineering Department,
Worcester Polytechnic Institute.

The new building which has been erected the past year, as a home for the department of electrical engineering at the Worcester Polytechnic Institute has been developed along lines which are in many respects unique among buildings of its class and a description seems worthy of presentation before this Society as of probable interest to many of its members.

The department of electrical engineering was established at the Worcester Polytechnic Institute in the year 1896, and space was assigned for its work in the Salisbury Laboratories and in the Power laboratory, which was ample for the first few years, but rapidly became inadequate, as may be seen from the following table showing the growth in registration of students taking the electrical engineering course at the institute.

Front View, Electrical Engineering Building.

Year Ending June.	Students Registered in Electrical Engineering.
1898	46
1900	57
1902	71
1904	98
1906	141
1908	160
1910	200

The last two values are, of course, estimates, but can be determined with reasonable accuracy from data now available.

The building was planned by the members of the electrical engineering department, with a view to the existing conditions and the probable accommodation necessary for students during the next few years. The various features are, therefore, designed to accommodate easily and conveniently a total registration in the department of 275 to 300 students, with a distribution for the work in the laboratories and class rooms of about the following proportion:

Graduate Students	15
Seniors	50
Juniors	60

While this is a desirable number of students to be accommodated with the facilities provided by the building and equipments now being installed, the common experience of technical schools, of growth beyond limits at present recognized, has been taken into consideration and, with slight modifications in the arrangements of the building and increase in the corps of instruction and in equipments, which could readily be accommodated without structural changes in the building, double the above registration could be taken care of without serious crowding.

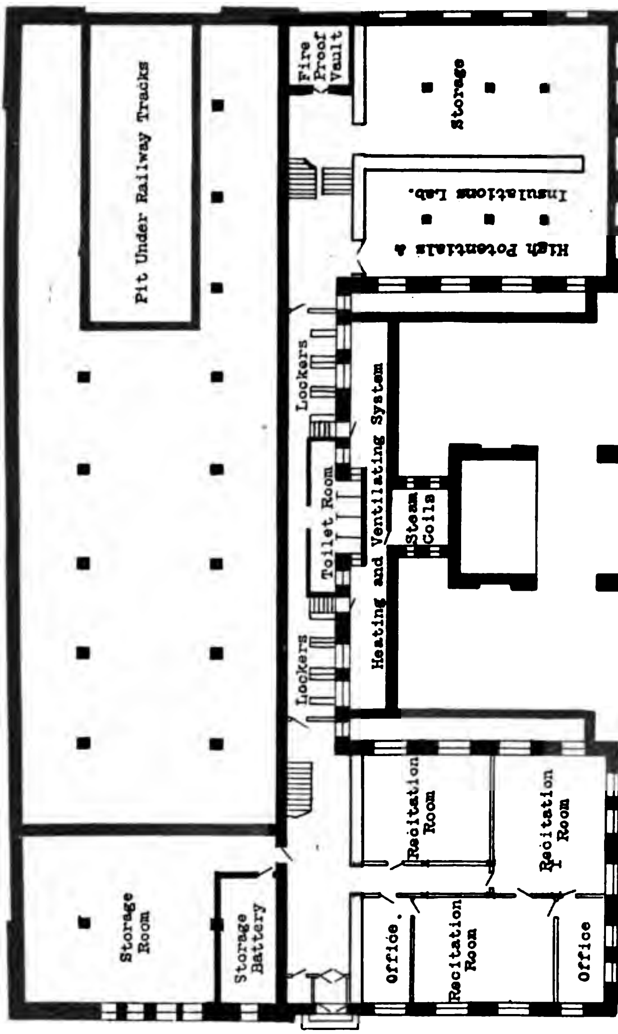
Rear and End View, Electrical Engineering Building.

The building, of which a view is given on p. 131, is the largest of the group of buildings on the institute campus. It occupies an area of about 20,000 sq. ft., with over-all dimensions of 122 x 200 ft., and is made up of a main rectangular structure, 67 x 200 ft., which contains the general laboratory 55 x 200 ft., and the main corridor 12 x 185 ft., together with two rectangular wings, 55 x 55 ft. each, and projecting to the front. The west wing accommodates a lecture hall, capable of seating 300 persons, with a standards and research laboratory above, each 55 x 55 ft. and free from columns. Under the lecture room is the high potentials and insulations laboratory 55 x 55 ft. In the east wing are located, in the basement, the telephone laboratory, two offices and two lecture or recitation rooms, while on the main floor are the department offices and library, and on the upper floor are found the design room, a lecture room, three offices and a blueprint room.

The site of the building is on sloping ground, which permits of full basements above the ground level for the two wings and corridor, with entrances at east and west ends of basement corridor; while the first floor of the general laboratory is at the ground level, giving entrance at the west end to the railway tracks. which connect with the local street railway system. The main building is, therefore, but two stories high, with third floor gallery. The wings are three stories in height.

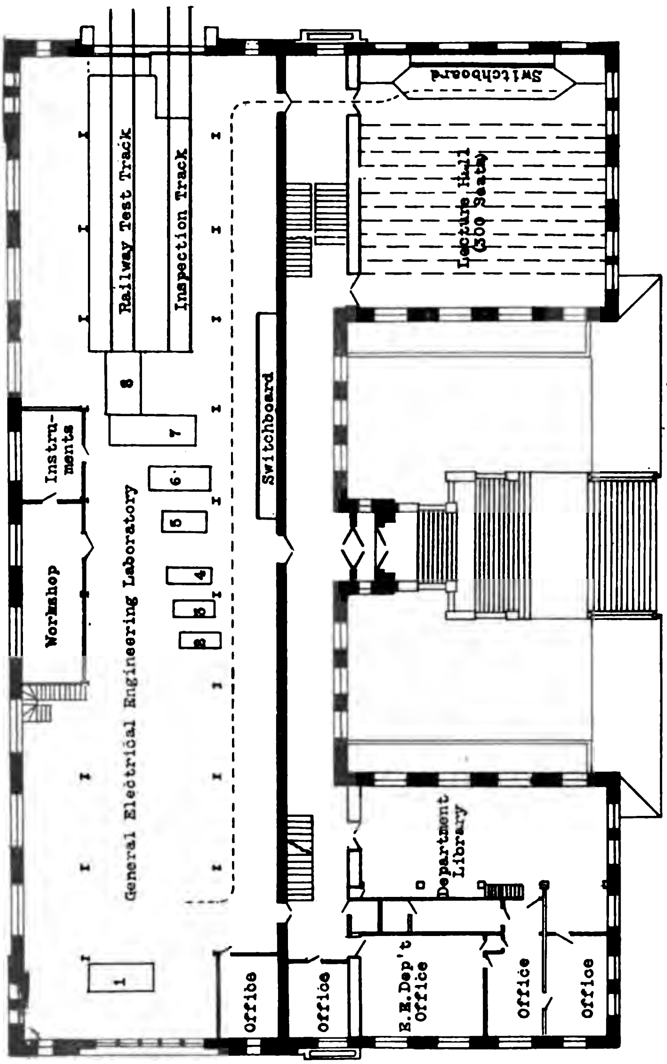
All foundations are of concrete, which extend somewhat above ground and are finished on the exterior by rough picking.

Lecture Hall, Electrical Engineering Building.



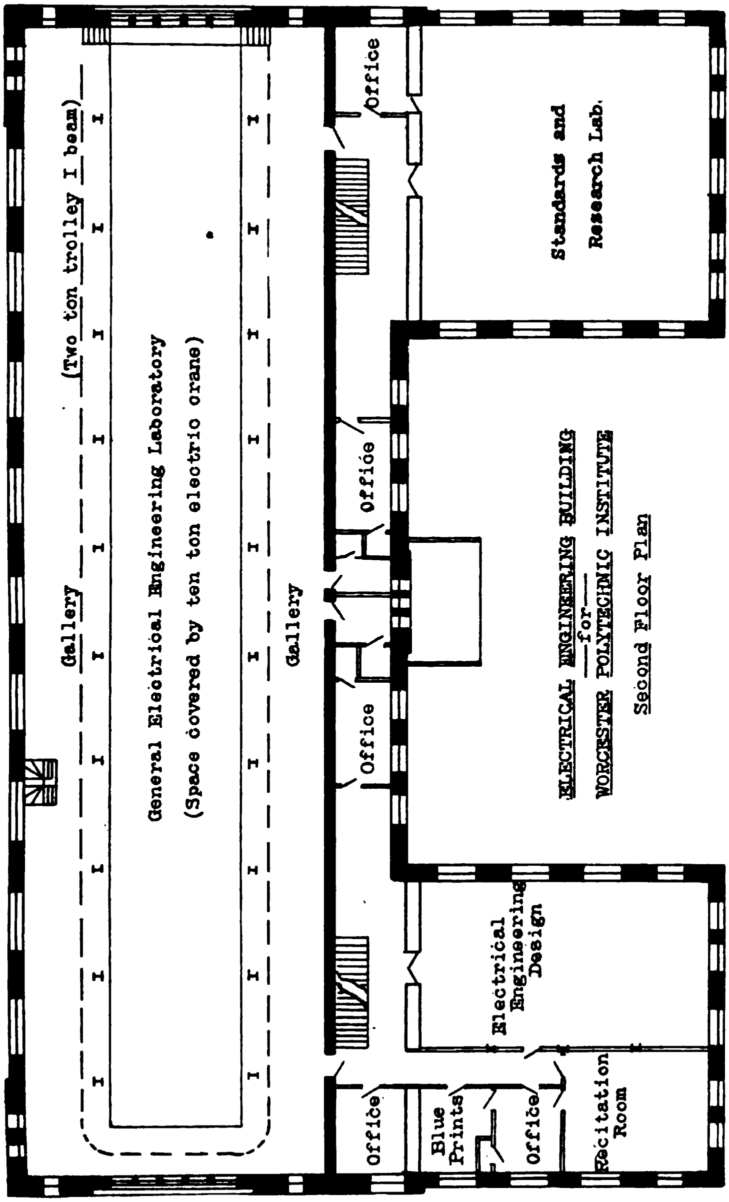
Basement Plan

ELECTRICAL ENGINEERING BUILDING
—for—
WORCESTER POLYTECHNIC INSTITUTE



First Floor Plan

ELECTRICAL ENGINEERING BUILDING
for
WORCESTER POLYTECHNIC INSTITUTE


ELECTRICAL ENGINEERING BUILDING
—for—
WORCESTER POLYTECHNIC INSTITUTE
Second Floor Plan
Gallery
(Two ton trolley I beam)
General Electrical Engineering Laboratory
(Space covered by ten ton electric crane)
Gallery
Office
Office
Office
Standards and Research Lab.
Electrical Engineering Design
Office
Blue Prints
Office
Recitation Room

The walls are of red sand-struck brick, trimmed with brown sandstone and special dark brick. All brickwork was laid in 1 to 3 Portland cement mortar. Roofs are of green slate and copper.

The framing is of steel columns, girders and roof trusses, with beams and rafters of southern pine. Floors are of three-inch spruce plank, with seven-eighths inch maple top, except in basements and in the general laboratory, where concrete floors are used. Roof planking is of two-inch spruce. All timber and under sides of floor and roof planks are dressed and exposed in open framework. Minor partitions in the wings are of plaster on wood laths. Partitions about the instrument room and the workshop in the general laboratory are of sheathing. Interior brick walls are painted and exposed framing and plank ceilings are either stained or oiled. Doors and interior wood finish are of red oak, with dull rubbed finish.

While in no sense fire-proof, the construction may be termed "slow burning," and the fire risk is somewhat reduced by the brick fire wall which separates the general laboratory from the corridors and the wings. All openings in this wall are provided with automatic fire doors. Fourteen lines of two-inch hose are placed in the building and have connection to the city high service system.

The framing in the general laboratory gives a center bay 28 ft. wide extending the entire 200 ft. of length, and supports the track girders, upon which a ten-ton electric travelling crane is operated. The crane accommodates the entire center bay and can land loads on the second floor gallery, which extends

Interior of General Laboratory, Electrical Engineering Building.

entirely around the room. The side bays are 12 ft. in clear width, with the second floor galleries 14 ft. wide, because of two-foot cantilever projection into the center bay. On the third floor level, a gallery extends the full length of the building on the north side of the laboratory. The galleries are served by two-ton trolley hoists, covering their entire length and in the first story connecting with the lecture room, so that apparatus from the laboratory may be easily placed upon the lecture platform.

The concrete floor of the general laboratory, supported on the soil except over the storage room at the east end, where a reinforced concrete floor preserves the continuity of the surface, is provided with cast iron bolt sockets, spaced four feet on centers, to permit of fastenings for laboratory apparatus. The central portion is made ten inches thick to provide for heavy machines, and is underlaid with ducts and hand holes for wiring to the apparatus located in this section.

The building is furnished with both live and exhaust steam, by pipes from the central station of the institute. Direct radiation is used for heating the large laboratory and is the principal source of heat for the entire building. For ventilation of offices, recitation, lecture and design rooms, air from a heating chamber, located under the front steps, is forced through tunnels and ducts to these rooms, while vent ducts exhaust through the roof of each wing. The Webster vacuum return system is used throughout.

The lighting is accomplished mainly by 220-volt incandescent lamps, with holophane shades. How-

Test Car and Car Testing Equipment.

ever, to meet special requirements or for purposes of illustration, most of the methods of artificial electric illumination may be found in the building. The general illumination of the general laboratory is secured by flaming arcs, supported so that they may be conveniently trimmed from the crane, and special lighting under the galleries and elsewhere in the room is provided by incandescents. Concentric diffuser arcs, nernst lamps, arc bursts, mercury arcs, etc., are used in appropriate locations.

The power supply is brought from the power laboratory of the institute at 2200 and 220 volts, 2-phase, 60 cycles, alternating current, and at 220 volts direct current, the larger proportion being at the higher voltage, at which a maximum of 450 kw. is available when necessary.

The final design of the building was placed in the hands of Messrs. Peabody and Stearns, of Boston, while the director of the civil engineering department at the institute was consulting engineer and superintendent of construction.

The construction was done by contract with the Central Building Co. of Worcester, at a cost of about $125,000, including separate contracts for heating, lighting and ventilation. The cubic contents are about 910,000 cu. ft., giving a cost of 13.7 cents per cubic foot. The total floor area is about 43,000 sq. ft., distributed approximately as follows:

	Per Cent.
Laboratories	50
Corridors and halls	13
Storage space	12
Lecture hall and recitation rooms	11
Offices	6
Design room	5
Library	3
	100

The building was completed May 15th and dedicated June 13th, 1907.

The equipment of the building and laboratories is rapidly going forward, with much of the equipment already in place, and it is expected that, by September, practically all of the equipment at present contemplated will be in commission.

The power for the laboratory is supplied at 2200 volts by underground cables from the power laboratory of the institute, where have been installed three service units, which are in charge of the electrical engineering department. These units are supplied with steam from four boilers, aggregating 560 horsepower nominally, but capable of considerable overload. These units consist of direct connected two-phase, 60 cycle generators and engines of 75, 175 and 350 horsepower, respectively, and are controlled by a switchboard of eleven panels, which will permit separation of service and experimental loads. The equivalent of nearly 2000 incandescent lamps and 25 induction motors, aggregating 350 horsepower of motors and lights, are connected, not including experimental equipment. The circuits of this system, because of their varied application, illustrate most of the methods of electric power transmission and distribution, and possess many features of

educational value besides their primary function of service to the institute.

The large general electrical engineering laboratory contains some fifty generators and motors, including examples of all the principal commercial types and a number which have features designed especially for experimental purposes. In capacity, these machines vary from a 300-horse-power motor, 200 kw. generator and 150 kw. transformers, down to machines of 1 kw., or less. The aggregate capacity of equipment for the laboratory is about 1500 kw. or 2000 horse-power.

The transformer equipment numbers over forty and includes the regular commercial types and several of special design. Among the latter are one giving 500,000 volts and two others of 200,000 volts and of 100 kw. capacity each. There are four transformers of 150 kw. capacity with taps for two- or three-phase operation. There are six auto-transformers with taps for multi-potentials and polyphase work.

The collection of arc lamps is very complete and contains lamps of wide variety of type by the various makers.

Partly of standard equipment and partly of special design is the electric railway apparatus. Two tracks, connecting with the tracks of the local railway company and in that way with the suburban and interurban railways of New England, enter the laboratory on space covered by the travelling crane. One of these tracks, for purposes of inspection, is for its entire length over a pit. The second track leads to a testing plant, where a car or locomotive under test rests and runs on wheels carried by axles which trans-

mit the power from the car to special electric absorption dynamometers and fly-wheels. The pedestals carrying these axles may be moved to accommodate cars of any truck or wheel base, and the fly-wheels are so arranged that their weight may be changed to correctly represent the inertia of cars of any weight within wide limits. The car is held in place over the supporting wheels by an end post, which will transmit the drawbar pull to a traction dynamometer. A very complete set of recording instruments measures the power consumption, speed, tractive effort, etc., of the car under test. A complete, double-truck, four-motor interurban car is a portion of the equipment. This car is fully equipped with special apparatus and will be available for testing work, either upon the stand in the laboratory, or on lines of electric railways outside. Besides the equipment mounted on the car, the laboratory contains various types of motors, braking, controlling, lighting, heating and signalling apparatus, mounted in such a way that their operation may be studied and tests made.

The standards and research laboratory equipment is in process of development and contains instruments by the best makers, as well as standards of the various electrical units. There are curve tracers, oscillographs, special generators and a large collection of special instruments. The valuation of equipment in contemplation for immediate installation, including that removed from the old laboratories, is about $125,000, thus making a total valuation of building and equipment of about $250,000, at the beginning of the next college year, to which additions of equipment will be made from time to time.

THE ORGANIZATION AND CONDUCT OF AN ELECTRICAL ENGINEERING LABORATORY.

BY JOHN W. SHUSTER,
Assistant Professor of Electrical Engineering, University of Wisconsin.

In what is contained in this paper the considerations are made with special reference to a laboratory organization suited to the needs of an electrical engineering course. Many of the statements, however, will be applicable to mechanical and other engineering courses.

In the early years of the development of technical education there was a misapprehension on the part of certain employers as to the kind of product an engineering college should be expected to turn out. The fact that professional studies are pursued for two or three years, and that laboratory practice is given to supplement the class work, led these people to look upon graduates as men on whom they could immediately place the responsibility of engineering work. Those who expected finished engineers were, of course, disappointed, and in some cases this disappointment led to their disapproval of the whole plan of technical education.

The differences of opinion which have existed between practising engineers and teachers of engineering have largely disappeared, and the members of the profession have come to a better understanding than formerly as to the scope of the technical school

and the results which it may hope to obtain. Both the schools and practising engineers are to be congratulated on this mutual agreement, as the mutual help which may be obtained by the cooperation of these forces is of immense value.

The province of the technical school is that of laying a broad foundation for a subsequent engineering practice. The finished engineer cannot be developed in an engineering school, even if it maintain an extended graduate course of study; much less in four short years, two of which are devoted almost exclusively to subjects which might well be required for admission to a professional school. The handling of apparatus which in its operation carries out and exhibits, in the flesh as it were, the principles over which the student has labored faithfully, and not always with complete success, will do more to illustrate those principles and fix them firmly in memory than any other agency working for an equal length of time. The numerous thoroughly equipped and well appointed laboratories, both in pure science and engineering, attest the appreciation in which experimental instruction is held.

From the above it will be clear that the writer is a believer in the use of laboratory instruction, from the standpoint of inspiring clear thinking and fixing fundamental principles firmly in mind, rather than the other view which is sometimes held, viz: that the purpose of such work is to train men in the methods of precise measurements. That is, the prime object of laboratory instruction is, to illustrate, discover and fix fundamental principles rather than to teach

methods of making commercial tests. Facility in handling apparatus and making tests will, of course, aid the young engineer in any experimental or testing work which he may take up after leaving college, but clear conceptions and ready interpretation of results is of much more importance.

In the organization of a laboratory for instruction in electrical engineering, there are several factors which should receive especial attention, among which may be mentioned:

1. The personnel of the instructional force.
2. The selection and arrangement of laboratory equipment.
3. The arranging of classes in proper sections and divisions.
4. The selection of texts, reference matter and forms, if any or all of these are to be used.
5. The reports which are to be required, and the credits to be given for the work.

In order that there may be harmony of purpose and method in conducting laboratory work which is so closely allied as is that usually given in direct and alternating current machinery, it is desirable to have the supervision of this work in the hands of one man, who takes the initiative in outlining the work to be given and who is in close touch and sympathy with the corresponding work as it is being conducted in the classroom. A sufficient number of instructors should be available so that the number of students in a section under the supervision of any one instructor shall not exceed ten, and a limit of six or eight is preferable.

The assignments of these instructors should be such that they have ample time to devote to the careful correction of reports, for conferences with their students, for preparation of their subjects by outside reading, etc., and for carrying on experimental and investigative work looking toward productive results. The men for these places should be selected with care, securing men who are easily approached, enthusiastic, and closely in touch with their subjects and students. During the laboratory period, when supervising experimental work, the type which is "wise as serpents and harmless as doves" is ideal. By this I mean that the instructor should know everything that is going on in his laboratory without giving the impression to the student that he is being watched. He should be very careful about giving information which the student can obtain for himself, with a little thought and ingenuity.

In the selection of apparatus, the machine or instrument which best illustrates the principles involved in its operation is the most valuable. Where the same results may be obtained through the application of entirely different principles, a number of different types is desirable. A good illustration of this is found in the electrical indicating instruments. While I believe representative types of instruments should be available in an experimental laboratory, I would not recommend the use of these instruments indiscriminately in taking data in which great accuracy is to be required.

The equipment of dynamos, motors, meters, transformers, etc., should include representative types;

and, in the interest of economy which most of us have to practice, it is desirable that a standard of capacity and voltage be somewhat closely adhered to. This will result in a very great saving, especially in the duplication of instruments.

The building should be pleasant, well-lighted and ventilated; and as free as practicable from vibration.

In assigning work to students, it is found that in most cases two of the brighter and more aggressive students will do practically all of the work, and if there are other men in the division, they will get comparatively little benefit from the experiment. The arrangement of a section into divisions of two, giving these free use of the apparatus, and requiring them to plan and execute their work as independently as possible, has resulted in a very marked development of the men, both with respect to independent thinking and in dexterity of manipulation.

Of the prevailing methods of assigning work two will be mentioned:

1. The assigning of a particular characteristic to be determined and studied; as for example, the magnetization curve of a shunt dynamo.

2. The assignment of a piece of apparatus to be studied in detail; and to have all of its characteristics determined; for example, a complete study of a shunt dynamo.

In the opinion of the writer, the former method is especially adapted to work with beginning students. The point to be aimed at is clear thinking, and if the assignment is limited and specific, the student will ordinarily get a clear conception; while if the assign-

ment is general he is likely to become confused, rather than to obtain clear impressions.

For advanced students, and particularly for graduate work, the second method produces very satisfactory results. Several texts, or laboratory manuals, are available for this class of instruction at present, but, in order to properly coordinate the laboratory and class work in the same subject, it is preferable, if there is sufficient time at the disposal of the instructor and student, to assign the work one or two periods in advance, with a few of the best references on the subject, and require the student to present a satisfactory outline of the experiment with a diagram of connections before beginning his experimental work.

The use of printed forms should be considered with care, as there is a valuable element of training to the student in devising methods of arranging his data so as to make them most intelligible. If occasional lectures can be given to laboratory students, including among other things, some information as to the most effective methods of tabulating data and plotting curves, the printed forms may very well be omitted in most every case.

The laboratory report, written in the first person, in a clear, concise, accurate manner, is of inestimable value to the student. It gives him a feeling of having done something for himself, instead of having only absorbed information, to the effect that Professor A. says so and so, or Professor B.'s book has it stated in this way.

It is in connection with the original outline and the discussion of the final report that the instructor can

be of most service to the student. The student, having made an earnest effort to produce these papers, is in touch with the subject; and the instructor, by question or suggestion, is able to draw him out and aid him in seeing many things which had entirely escaped him previously. It is here that the enthusiastic, sympathetic, tactful teacher can be of great value to the student in assisting him to discover new facts without in any way destroying his initiative.

The credits to be given for laboratory work should be determined very largely by the thoroughness with which the reports are required to be prepared. The report is the best indication of the student's interpretive ability. It should be written in a clear, concise manner, and should be carefully corrected both with respect to the English and the subject matter contained.

In the electrical laboratory of the University of Wisconsin, one unit of credit is given for one and a half hours' work in the laboratory per week, the reports to be written up on outside time. This amounts to allowing as much time for the writing and correcting of reports as is used in performing the experimental work. This allows time for careful consideration and complete calculations of the data obtained in the laboratory.

I have referred to assignments for graduate students. Men who have reached this point in their study should be encouraged to follow out new developments and analyze their results carefully, looking to the discovery of new information, or to finding new applications for principles already known.

In conclusion, I would say that with able, tactful instructors and equipment carefully selected for *use*, the student being held responsible for apparatus in his charge, the engineering laboratory is one of the most important factors in producing the fertile graduate of to-day and the able engineer of to-morrow.

CENTRAL STATION DESIGN.

BY ALBERT A. RADTKE,
Professor of Electrical Engineering, Armour Institute of Technology.

Central station design is one of the courses given in technical schools for the purpose of correlating the theoretical training with its practical application. The difficulty in developing this power of correlating which insures to a great extent the success of the student in practice, is due mainly to the small amount of time that can be allotted to such courses, and it was in recognition of this difficulty that the writer developed the method here described which during the three years of its application at the Armour Institute of Technology has produced gratifying results.

At Armour Institute, as in most technical schools, this course is scheduled for the senior year in which it is allowed seventy-two hours in periods of six hours each. It is preceded by a course in the junior year which covers the principles underlying the steam equipment of a power plant and which is accompanied by numerous problems in the calculation and design of individual apparatus such as condensers, pumps, feed water heaters, and similar machinery.

At the close of this course each student, or group of students, is given a special assignment which is to be the basis of the work in central station design, and which consists of data on a system for which he is to design a plant. These data include the location and the size of the system, the character and distribu-

tion of the load, the coal and water facilities of the location, the kind of fuel available, its calorific value and cost, the rate of increase of the load and a load-curve showing the day of maximum output for the preceding year. These data are secured directly from central station managers operating systems in the middle-west by sending out blanks accompanied by a letter explaining the purpose and asking for their cooperation.

With this as a basis the student prepares a preliminary layout of his plant and calculations for his design. This is then gone over with the instructor, and a decision is made on the apparatus for his plant; also the type of system whether single or multiphase, the frequency and voltage, etc. The student then prepares a list of the apparatus needed for its equipment which is brought to the instructor. He is then supplied with templates of standard apparatus and machinery which fit his needs from the files of the department.

The student arranges these templates on his drafting board and when he has secured a practical and proper arrangement, pastes them in place on his detail paper and draws in the piping, breeching, stacks, etc., and building.

The number of drawings required of each plant are five:

A plan, ¼″–1 ft.

A sectional elevation, ¼″–1 ft.

A wiring diagram, no scale.

A front and sectional elevation of switchboard, 1½″–1 ft.

A piping plan, $\frac{1}{4}''$–1 ft.

In addition to handing in the required drawing at the completion of the term, he tabulates the calculation of apparatus and writes a discussion of the reasons why the various types of machines were chosen.

The templates have been made from blue prints secured from manufacturers of standard apparatus and machinery. These blue prints are then reduced to the $\frac{1}{4}''$ to 1 ft. scale either by the students or draftsmen and traced on tracing cloth. By this method there has now been collected a fairly complete series of templates of the standard machines. They include:

Prime movers, sizes up to 1500 kw.:
- Steam engines;
- Steam turbines; Curtis, Parsons.
- Gas engines; Allis-Chalmers, Westinghouse.
- Water turbines.

Condensers:
- Jet and surface; Wheeler, Worthington, Alberger, Baragwanath.

Pumps:
- Air, circulating, boiler feed; Dean, Blake, Worthington.

Boilers, all sizes up to 550 h.p.:
- Water tube; B. & W., Heine, Parker.

Exciter-sets, sizes up to 100 kw.:
- Steam-driven, motor-driven.

Mechanical stokers and chain grates:
- B. & W., Jones underfeed, Mackenzie, Roney.

Steam traps:
- For all sizes of pipes.

Feed water heaters; open and closed types:
  All sizes, for plants up to 6000 kw.; Hoppes, Goubert.

Conveyers:

Cranes:

Switchboard apparatus:
  Weston, General Electric, Westinghouse, Whitney, Bristol.
  Ground detectors.
  A. C. & D. C. voltmeters, ammeters, wattmeters, both indicating and integrating.
    Power factor indicators.
    Frequency indicators.
  Knife-switches up to 2000 amperes, both single- and double-throw and pole:
    Oil-switches for voltages up to 60,000, of all sizes.
    Overload time limit relays.
    Lightning arresters.

Transformers:
  Air-blast and oil-cooled, up to 1100 kw.,
  Current transformers,
  Potential transformers,
  Induction regulators,
  Arc light transformers and regulators.

The templates for the switchboard construction are made to the scale of $1\frac{1}{2}''$–1 ft., which is the standard adopted by most drafting rooms. The wiring diagram is not a scale drawing. An effort is made, however, to have all apparatus in the same relative position as in the plant.

In addition, the department has on file a number

of standard drawings of switchboard construction showing frames, bases, bus-brackets, fuse panels, etc. Also wiring diagrams for railway plants, single-phase, direct current, and also for power and lighting plants, substation wiring and construction. A complete file of catalogues and bulletins is kept to which the student has access.

With these sources at his disposal and the templates in blue print form ready to be used, the student quickly learns how to combine machines and apparatus into a practical layout or design.

The merit of the system is that it relieves the student of the drudgery of reducing all apparatus to scale, which would be an impossibility in the time allowed, and still retains all the valuable points to be gained from such design and the concrete expression of his ideas.

By increasing the number of templates each year and showing the students the work of the previous class, the designs increase in completeness and merit. The student is interested when he sees he is producing something making him of immediate value to an employer and strives to out-do previous work.

It also familiarizes the student with a standard drafting-room method and one he will undoubtedly have to learn soon after leaving college, if he does not while there. It also enables him to produce results quickly, an additional virtue which central station managers and manufacturers will place to his credit.

The success of the work is mainly due to the fact that the student feels that in solving a problem based

on actual conditions he is producing more than a mere design, something of tangible value. In many cases the student spends more than the required time upon this work and makes, of his own accord, additional views, such as a transverse section through the plant, a view showing coal conveyors and bunkers in detail, etc.

The writer plans that the future may allow him to expand this method to the extent of having the student estimate the cost of the installation and, perhaps, to calculate the return on the investment, assuming fixed charges and a proper operating cost. To the extent that it has thus far been carried, there is no question as to its value.

JOINT DISCUSSION.

PROFESSOR RADTKE: I would like to say a word in regard to Professor Schuster's claim that ten is the number of students that can be taught to advantage at one time in a laboratory. I think ten should be the maximum, but as a student becomes familiar with the instruments and machines, the number can be increased. As the number increases toward the end of the college course, an instructor may have as many students inside the laboratory as it will hold. It is only essential for the beginner to have such exact provision as Professor Schuster has designated by his paper.

PROFESSOR BRACKETT: We have always had a great deal of doubt about those students who naturally depend upon others to do the work for them in the laboratory. Even if only two are working in a

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group, there is often a tendency for one to depend upon the other for the observation. For quite a number of years I have questioned whether there ought not to be regular examinations or tests on laboratory work in addition to the reports. If reports are written outside the school it is possible for a report to be more or less excellent in form, and yet the student may have no clear understanding of what that experiment means. In my own experience I think something more is needed in the laboratory than carefully watching what is done. I think in the actual process of the work, quite an amount of questioning and cross-questioning is beneficial. Questioning may be used to develop a full comprehension of the work without telling the student what he should do. With some this is quite necessary; with others it is not even desirable. In this way laboratory work broadens to individual instruction, and that instruction is not directed to calling the student's attention to the things he should have observed, but to requiring him to make the observation himself, in order to answer the questions asked.

Moreover the answers to questions asked in the laboratory may take the place of the examinations in the case of students whose experimental ability is in doubt.

Professor Caldwell: We have developed at the Ohio State University in the last few years the practice of requiring final examinations in laboratory work from all students, examinations of the same character as are required in the classroom courses, and have come to feel that this is an essential part of laboratory

work. We find it best not to give the students printed forms for their tests. It is very important that they should learn to tabulate matter without having it all laid out for them in advance. Giving lectures is an excellent solution of this problem. We give no practice in central station design to our electrical engineering students, giving only design work in wiring, transformers and dynamos. We simply use the design method as an additional means of enforcing the theory of the dynamo, etc. I am, therefore, interested in this proposition of giving so much time to central station design.

PROFESSOR WOOD: The question has been raised in our laboratory work at the Pennsylvania State College, and after some careful consideration we have found the best solution lies in following the student direct from classroom into the laboratory, where his special difficulties may be cleared up. It gives the instructor a chance to make sure that the students see the application of the theory. Last year I had a class of over thirty in thermodynamics. They were divided into three sections for laboratory work, and, by following up the individual men, I brought the entire class up to a more uniform standard than might have been possible had another instructor taken them in the laboratory, simply because it was *individual* instruction combined with classwork. When it came to examination, it was not surprising to find that the grades approximated those for laboratory and the only failures were with those who had also slighted their practicum. Does not this simple method answer many of the points raised in our discussions here?

If conditions prevent the carrying out of such a method to the extent I have indicated, the next best arrangement would seem to be a genuine cooperation between the teachers in the classroom and in the laboratory.

Professor Dates: Some men are in favor of using the regular laboratory textbooks. Most of these books on the market are quite profuse. They go into the theory of experiment and the whole direction for performing it, etc. The other method that some adopt is to do away with the use of the textbook and make use of notes given by the lecturer in mimeograph notes, leaving a certain amount of work to be done by the student. It seems to me the objection is that men rely upon this guide in the laboratory too much. The problem arising with the second matter is a sufficient amount of knowledge to do their work successfully. They get a certain amount of reference work in advance. We have adopted the policy in our laboratory of largely doing away with the use of textbooks, and requiring a certain amount of reference in work, aiming not to tie men up to any one of the methods, but to have them state the preliminary references on the subject and then go in and do the work. We feel that this develops the individual man and puts the problem to him in a better way than the textbooks, which tell him too much, and leave little or nothing for his own working out. I would ask Professor Schuster what method he pursues in his very successful work.

Professor Morgan Brooks: There is still another kind of laboratory work—practice in operation, or

imitating central station conditions. For example, training a student to transfer a load quickly from one dynamo to another without noticeable disturbance; also charging a storage battery by the several commercial methods required in practice under service conditions. The student not only gains facility in operation, but is interested in the methods that may be devised to improve central station service.

Professor Schuster: There are one or two points I would like to take up briefly in closing the discussion. One is with reference to the number of students in the laboratory. My experience has been different from that of Professor Radtke. As far as the number of men who can be supervised at one time by any one instructor is concerned, I should very much rather supervise ten men in direct-current work than an equal number in alternating-current work. Of course, for the first two or three periods it might be more difficult to supervise the beginners until the men had learned the arrangement of the apparatus and circuits in the laboratory. In our laboratory I have always tried to arrange the alternating-current men in sections of six, while in the direct-current work they sometimes run up to ten, and occasionally twelve or fourteen. But that is not common.

In regard to the question raised as to the students depending upon one another, of course, that is something you cannot get away from. In the division we make in our laboratory we allow the students to select their partners and they are usually pretty well mated. In order to get good results from the poor man, we try in every way to correlate our work, and

the instructor in the classroom, as well as those in the laboratory, try to build up a sentiment in favor of doing the work for the work's sake, and not for the credit they will get for the result. We are able to get quite satisfactory results from the slow man by asking him questions and giving occasional suggestions during the experimental work. I intended to cover that, in a way, by what I have said about qualities of instructors. The instructors should know just what the men are doing and how they are getting on with the work at all times. They can tell this very closely by keeping on the alert, and knowing what connections have been made, etc., without doing very much in the way of questioning the student. The questioning of the student, and teaching him at the time just what he ought to observe, is likely to develop in the student a dependence that the instructor should avoid, and it does not develop men as laboratory work ought to develop them. If the instructor keeps in touch with the student in his conferences on original outlines and final reports, he can find out what the man knows about his subject, and if it seems necessary the student should be required to repeat the experiment until he understands it. In regard to the textbook question, we have used a textbook to a considerable extent for laboratory work, due to the fact that as a rule the instructors have not had time to give the attention which outlines would require. A certain amount of work has been done by outlining the work and giving the references and having the students prepare their outlines and arrange for their work. I recommend this as being the preferable

method, if there is sufficient time available to both the instructor and the students. I have followed it to a considerable extent. In regard to Professor Brook's suggestion, that is simply a detail as to assignments of work. I remember a time when some students of mine wanted to do work similar to that which Professor Brooks outlined, and they put in two and a half days during a vacation in making up the connection for one single experiment. When they had finished they had most of the apparatus in the laboratory in operation.

PROFESSOR RADTKE: Perhaps I did not emphasize sufficiently the statement that the electrical engineering course, or any engineering course, is not a final one. The student has then about completed his theoretical training, and he is going to make an application of it. His success depends on whether he can connect up what he has learned with what he will find in engineering practice. Special attention should be paid to ensure to the student having developed his power and ability to correlate his theoretical training to its application.

BASIC PRINCIPLES IN THE CONSTRUCTION OF A TEXTBOOK.

BY S. E. SLOCUM,
Professor of Applied Mathematics, University of Cincinnati.

The most promising feature of modern scientific and technical education is the widespread and growing interest in the improvement of present methods of instruction. This agitation for improved pedagogic methods is not confined to any one locality, but is general throughout England, Europe and America. It is, in fact, a manifestation of the modern spirit which tends increasingly to specialization, and which has classified teaching, among other professions, as a science rather than an art.

In common with all great truths, the fundamental principles underlying scientific pedagogy are characterized by two distinctive features, simplicity and naturalness. In the engineering profession it has long been recognized that the sole function of the engineer is the utilization of natural forces in the simplest and most efficient manner. By reason of the fact that mental processes are more elusive than physical, this idea has been longer in penetrating the teaching profession. Its acceptance, however, lies at the basis of scientific pedagogy, and it is now generally recognized that the chief aim of the teacher, whether in the class-room or through the textbook, is not merely to impart information, but to direct natural thought processes to a particular end.

To accomplish this purpose there are at least three essential requisites; the stimulation of interest in a particular subject, the utilization of this interest for the mastery of the fundamental principles underlying the subject, and the acquirement of proficiency in their practical application.

The relation of interest to instruction is one of the most important problems of pedagogy, and as such has received careful study, notably by Herbart and his school. To arouse interest is practically to put the mind in a receptive attitude, and such a preparation of the soil for the seed is obviously of fundamental importance. Without going into a scientific discussion of interest, it may be said that interest depends on the completeness of the apperception. In other words, an idea is interesting in proportion as it is related to other ideas already familiar. Instruction must therefore proceed through a chain of related ideas, the more fully each idea is related to previous experience the more rapid being its assimilation and the greater the interest aroused. In short, education is a process of growth rather than of accretion, and for growth continuity is essential.

This fact is often overlooked, especially in mathematical instruction, where the mistake is frequently made of setting up a series of definitions as the basis of presentation, and teaching the subject as an exercise in formal logic. A definition, however, is an isolated idea and can be of no vital interest until it is related to experience. To be able to mechanically follow out the results of a definition is not the aim of instruction, and teachers who rely upon their weight

of authority to attain this end are unscientific as well as unpractical. To produce the continuity essential to growth, elementary instruction should therefore begin and continue with familiar things, following inductive methods, and waiting until thorough familiarity with the subject in hand is acquired before attempting to summarize knowledge in rules and formal definitions.

Closely connected with the question of the stimulation of interest is that of the sequence of development most favorable to the mastery of fundamental principles. This is also a psychological problem, but its solution is found at once in the simple fact, long since established, that the mental development of the individual follows the same course as that of the race, or, as Herbert Spencer expressed it, that the mental development of the individual is but a repetition of civilization in miniature. Since education means normal mental growth, it is apparent that the historical sequence of development is that which should be followed by scientific instruction. This so-called historical principle has been almost entirely overlooked by mathematicians and engineers, probably by reason of its extreme simplicity. It is, however, of fundamental importance to scientific pedagogy, especially in such subjects as mathematics and mechanics, which by reason of their long history afford an unusual opportunity for its application. The need of a universal criterion of instruction seems to be widely felt, and that furnished by the historical principle satisfies all demands, being simple and practical in its application as well as powerful in its results.

To illustrate the practical application of the historical method, a few instances may be cited from mathematics and mechanics. In elementary mathematics, the history of the subject indicates that instruction should begin by teaching addition as a method of counting, multiplication as an abbreviation of addition, involution as an abbreviation of multiplication, and subtraction, division and evolution as their inverses respectively. Logarithms should then be immediately introduced, and may be simply illustrated by the construction of paper slide rules. Logarithms were invented to supplement involution, and their introduction at this point adds greatly to clearness, especially if the word logarithm is dropped and they are called simply exponents. Calculation with five and seven place tables may be conveniently deferred until the student is farther advanced and greater accuracy is required than is possible with the ordinary slide rule. The remainder of elementary algebra should consist chiefly in an inductive proof of the binomial theorem, followed by the elementary theory of equations, including graphs. Ratio and proportion should be omitted as irrelevant, and the treatment of series reserved until demanded by the development of the calculus, where the history of the subject shows that it properly belongs. The introduction of graphs in the theory of equations is in strict accordance with the historical principle and the law of continuity. Not only does such correlation elucidate both subjects, but it also establishes a new series of connections between two branches of mathematics which students usually have difficulty in associating,

a difficulty due chiefly to the present artificial separation of algebra from analytical geometry.

In the calculus, history indicates that the fundamental idea is that of a limit, and that the subject should be approached by simple geometrical illustrations of the same. Algebraic illustrations of limits, including a discussion of series, should then be introduced, from which the idea of a differential coefficient follows by a simple natural transition and without formal definition. The definite integral as the limit of an infinite series also becomes immediately intelligible, and the whole subject takes on a rational unity too frequently lacking at present. To base the calculus on definitions is obviously unnatural and therefore unscientific, giving students the idea that the subject rests on an empirical basis, which is undoubtedly the cause for the distrust with which engineers sometimes regard its practical applications.

In mechanics instruction is greatly simplified by following the historical sequence of development, as experience clearly shows. Although natural science began with the investigation of the laws of the lever, history proves that mechanics remained for centuries where it was left by Archimedes, little or no progress being made until it was approached from the standpoint of motion. In fact, such an elementary principle of statics as the parallelogram of forces was not understood or even commonly accepted until Newton's laws of motion had led to a new conception of mechanical principles. The fundamental difficulty in the way of beginning instruction in mechanics with a course in statics has been remarked by many teach-

ers. For example, the principle of virtual work is unintelligible to most students when stated as a principle of statics. D'Alembert's principle as applied to motion, however, is easily understood, and from this the principle of virtual work is readily deduced and its true significance made apparent. The time-honored custom of making statics the basis of mechanics is therefore not justified, either theoretically or practically, and a great saving in energy, both to pupil and teacher, results from beginning the subject with kinematics and the laws of motion.

The law of continuity and the historical principle serve only to indicate the natural course for the acquirement of mental power, and the question of its utilization still remains to be considered. This involves the question of the aim of education, as to which there are widely divergent views. One extreme, which may be called the academic view, regards education merely as formal mental discipline, and gives the preference to those forms of instruction which someone has characterized by saying that they "cannot be made common by being applied to anything." The other extreme is the utilitarian, which judges everything by a commercial standard and reduces all values to their financial equivalent. The consensus of opinion indicates that the truth lies between these two extremes and inheres in the idea of service. By thus idealizing the commonplace, both extremes are avoided and yet both are satisfied as the practical is exalted while the ideal becomes in a measure attainable.

From this standpoint the work of instruction is not complete until it has bridged the chasm between the

theoretical and the practical. The teacher should remember that he is not educating the philosopher but the man of affairs, and that practically all of his pupils, whether engineers or not, will spend their lives in dealing with the commonplace. The ideal of education is by no means to educate a youth out of his environment, for this always results in dissatisfaction and useless friction. It is rather to educate him through his environment, so that he may learn to use it for the attainment of higher ends. Formal and antiquated exercises, whether in the classroom or textbook, are therefore worse than useless, as they serve to obscure the ideal of service instead of strengthening it. The author of a textbook in particular can spend his time to no better advantage than in the selection of problems with reference to their vital interest and modern application, as in this way both interest and utility are secured.

Heretofore, the merits of a textbook have been largely a matter of personal opinion. With the increasing multiplicity of texts, however, the need arises for the establishment of a norm or standard whereby their relative merits may be determined. The existence of the Society for the Promotion of Engineering Education and kindred societies is in itself evidence that the need of such a scientific criterion is felt. A universal principle is needed, and to be universal it must be drawn from experience. The simple psychological principles here presented, as applied in the historical method and association with the familiar and commonplace, satisfy this requirement, and although so simple as to appear trite, are nevertheless of fundamental importance to any theory of engineer-

ing education which lays claim to being rational and scientific as well as practical.

DISCUSSION.

PROFESSOR FRANKLIN: I wish to take exception to one thing in the paper, and that is the insistence upon the importance of history in the teaching of the physical sciences. No doubt every organic structure must in its own development recapitulate the history of its race, but with a logical structure surely it is different; the finished philosophical product of the sciences is what is conserved and handed down from generation to generation, and old discarded isms are so much excrementitious stuff. We do not sufficiently realize that the structure of the sciences is a continuously growing organism which can no more feed on what has been discarded than an animal can feed on dung.

Elementary physics should not be taught by dragging a student for several years over the painfully erratic historical development of the subject; any way, "past time is a book with seven seals," and the historical method is a dim impossibility. Let students look at the physical world as it is, and manipulate it and reason about it.

PROFESSOR MAGRUDER: Professor Slocum takes exception to the use of definitions. I think the trouble with definitions in some textbooks is that they do not define. If a definition does not convey the desired idea and actually define, do leave it out. Do not tempt the student to cite cases not covered by the definition. Vague generalities are worse than the other extreme of quibbling over minutiæ.

METHODS OF STUDYING CURRENT TECHNICAL LITERATURE.

BY HENRY H. NORRIS,
Professor of Elecctrical Engineering, Cornell University.

It needs no arguments to prove that if students can be made familiar with current engineering literature they will take more interest in their studies. The difficulty is how to accomplish this object in the limited time at their disposal. Several plans are in use which it is hoped will be brought out in the discussion of this subject. The writer will confine himself to his own experience, relying upon others to supplement the suggestions made.

It is impracticable for students to read continuously the periodicals relating to the profession and some selective principle must be applied in order that time and "eye-power" may be economized. Whatever time is thus employed should be expended systematically and some record should be kept of the information gained from the reading. I have made it a practice to encourage my students to subscribe for some first-class electrical periodical (mentioning several) with the idea that with the copies of such a periodical lying on their desks they would at odd times glance through the pages and be attracted by matters of interest. A bulletin board has been provided in the main lecture room and students are requested to post thereon such facts as have come to their notice through the periodicals and which they

think will interest their classmates. The remarks made by students indicate that a large number of them read the periodicals with more or less regularity, as they call attention to facts almost immediately upon publication. Formerly it was found desirable to arrange for rates for the different periodicals giving the students the benefit of the ordinary agents' discount. Lately, however, the publishers have discouraged this practice, as they feel that it conflicts with the interests of regular agents. At the present time, therefore, student agents are recommended to any publisher who desires to bring his periodical to the notice of the engineering students. Through the efforts of Professor H. Wade Hibbard, of the Sibley College faculty, an excellent periodical room was established some years ago and reading tables with magazine racks are located in an attractive part of the Sibley College buildings. These tables are usually filled during the term time and the students appear to examine the magazines diligently. In some departments, systematic seminary work is conducted among the undergraduates, but in the department of electrical engineering, on account of the large number of students, this is found at present impracticable. In the graduate seminary, however, considerable attention is paid to the periodical literature.

The technical papers contain too much material to be assimilated by undergraduate students and they are apt to be discouraged by its very abundance. They are not prepared to appreciate the highly technical articles and the descriptive articles are usually too elaborate for their purposes. The digests of en-

gineering literature, such as that published in the *Electrical World*, are of the utmost value. Any student should be able to read the abstracts of the articles which interest him most, and if time permit he can go to the original source of the information for further details. The problem is how to encourage the students to do this regularly, and further how to conserve the results of the study so that it may be of practical use to them. If the discussion can bring out some points regarding this matter they will be appreciated by all of the engineering teachers present.

DISCUSSION.

PROFESSOR WHITE: In some of our departments each senior is required to subscribe for a technical journal which he is responsible for indexing. These papers are kept in the department reading-room and are common property while there. The index cards are uniform in style and arrangement and copies are kept in the university library and in some cases in the library of the Western Society of Engineers in Chicago. We do not class this as seminary work and no credit is given for it.

PROFESSOR BRACKETT: I give one hour credit to junior and senior students for journal reading. I assign an article or more to each student at one of the weekly meetings. The next week each student is expected to have a suitable résumé of the reading assigned him and also to be prepared to answer any questions on the subject that may arise in discussion. As many as possible are asked to report each week.

PROFESSOR CHATBURN: We frequently ask our students toward the end of the semester to bring the textbook down- or up-to-date. If we are using a certain man's textbook published six or seven years ago, we ask our students to write an additional chapter for that textbook, using information which they can get from journals, magazines and other textbooks.

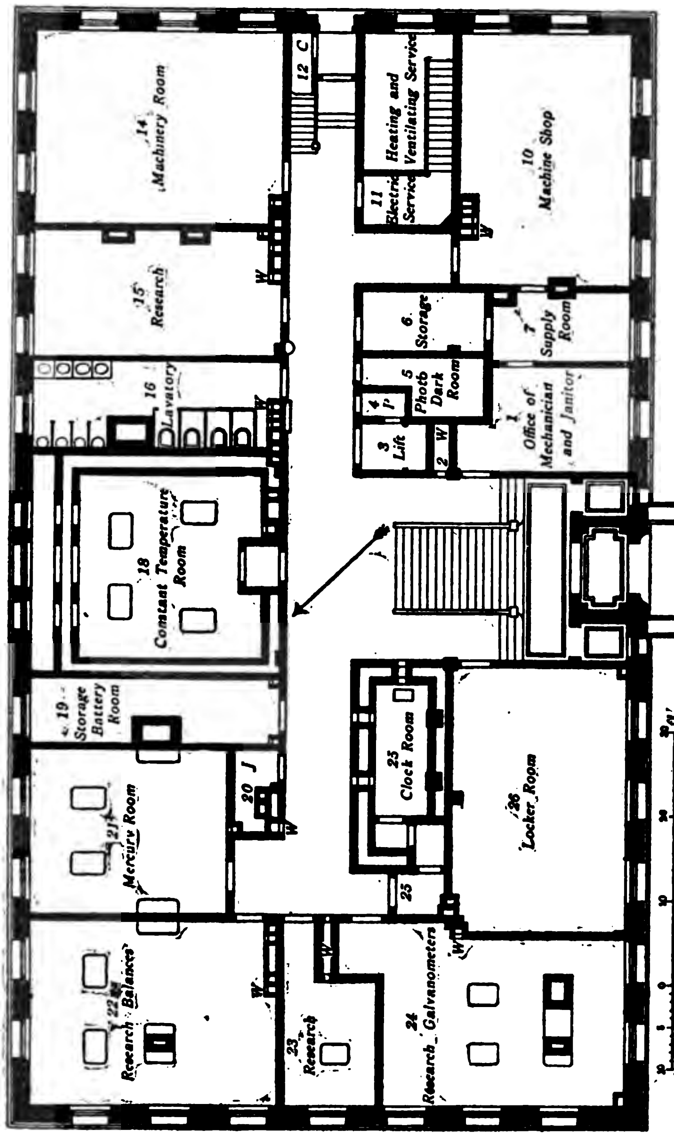
THE BUILDING AND EQUIPMENT OF THE ROCKEFELLER PHYSICAL LABORATORY OF THE CASE SCHOOL OF APPLIED SCIENCE.

BY DAYTON C. MILLER,
Professor of Physics, Case School of Applied Science.

A gift from Mr. John D. Rockefeller, made about two years ago, enabled me to materialize some plans I had long been making; the result is this building, which has been completed about six months. Really it is not yet quite completed as far as equipment is concerned. I wish very briefly to explain some general principles underlying the arrangement and equipment, after which you are invited to inspect the laboratories.

The purpose of the building is first to provide for the instruction of classes of two hundred and fifty students in general physics, including lectures, recitations and laboratory work. This determined some of the larger parts of the building. It has three floors and an attic, but no basement. The dimensions are 75 feet by 132 feet.

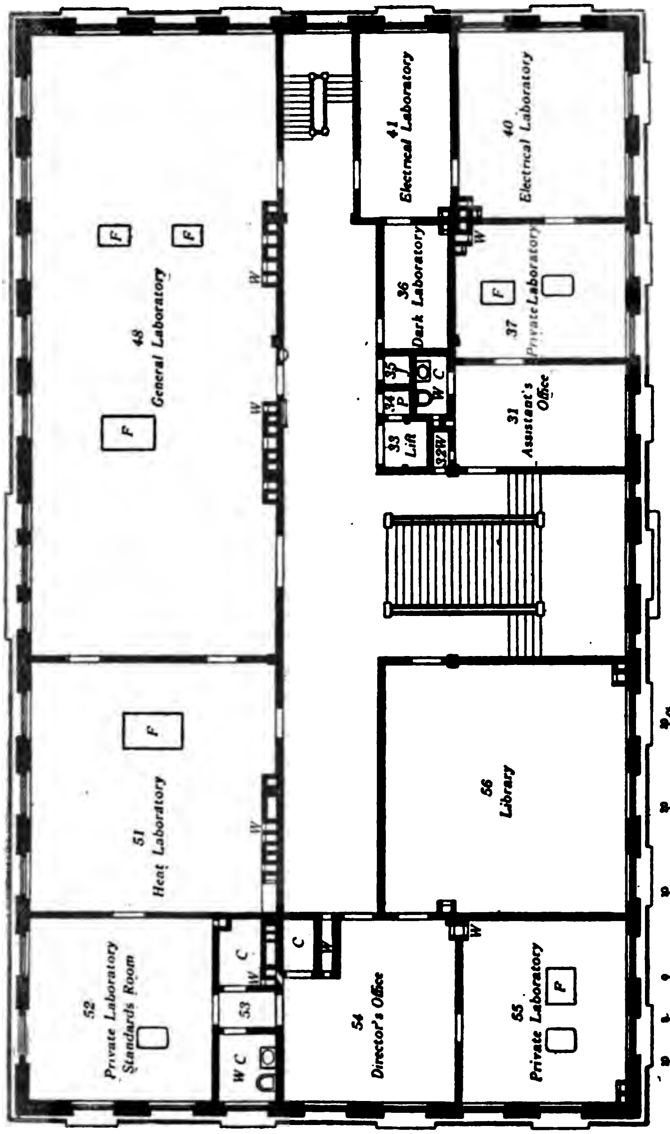
The work in general physics is provided for by a lecture room seating 250, with a preparation room adjacent, and by three recitation rooms, on the third floor; by a general laboratory consisting of one large room and four smaller rooms accommodating about 65 at one time, on the second floor; and by a locker room for 204, and a lavatory, on the first floor.



First Floor Plan, Rockefeller Physical Laboratory, Case School of Applied Science.

The students being thus accommodated, three offices were provided for the director and his assistants, and the remaining space was arranged for research. Adjacent to the director's office are two private laboratories, and connecting with the first assistant's office is a private laboratory, each having conveniences for special work. The other research rooms are on the ground floor and the third floor. Some of these are arranged for particular uses. There is a balance room, a galvanometer room, a room for mercury apparatus, one for machinery requiring considerable power, a constant temperature room with daylight for comparators and dividing engines, a constant temperature room for clocks and seismograph, photometer, spectroscope and photographic rooms, six dark rooms, a sound laboratory, a pendulum shaft, a battery room, a mechanician's shop and office, several small research rooms without special arrangements, a room for the heating and ventilating apparatus, janitor's closets, and storage rooms and several private lavatories.

There are about thirty piers in the building, and throughout there are wall shelves and outside window shelves. Many rooms are arranged for perfect darkening; conduits permit the running of wires from one room to any other, while 44 electrical circuits run from various points of the building to a central connecting board in the battery room, permitting many distributions and connections without special wiring. The distribution of gas, electricity, hot and cold water, steam, compressed air and exhaustion is unusually complete.

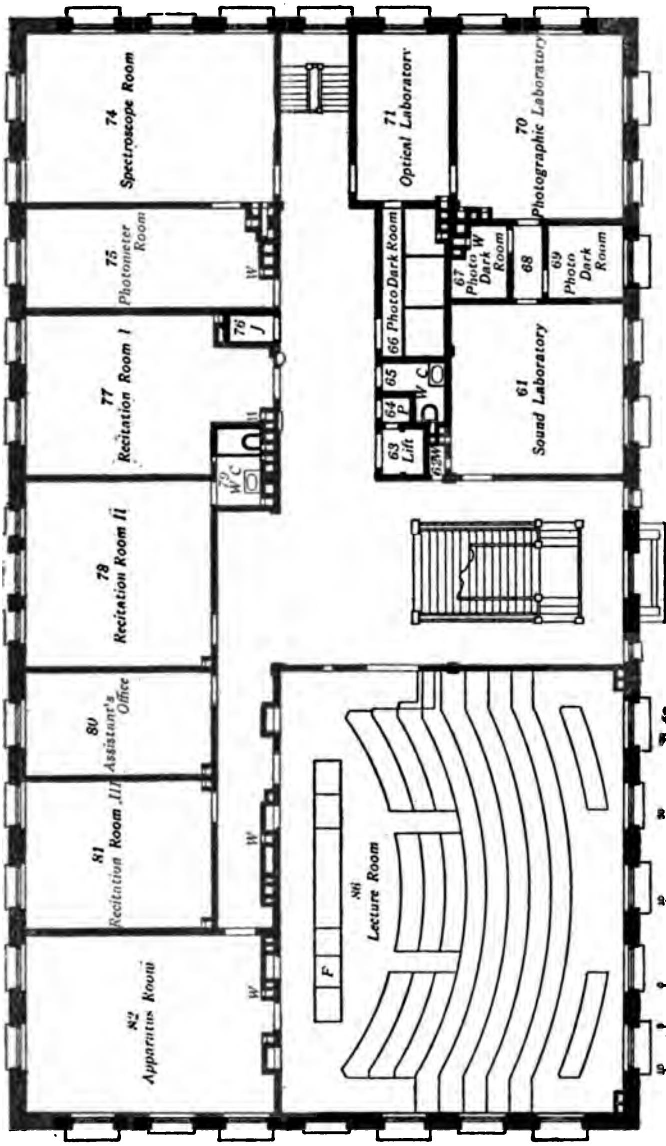


Second Floor Plan, Rockefeller Physical Laboratory, Case School of Applied Science.

The research rooms will accommodate 25 advanced students.

The equipment was planned upon a method similar to that used in designing the building; first, ample provision was made for the general laboratory and the lecture demonstrations; and then was added general apparatus suited to advanced work and instruments for special researches. Some of the special instruments are: meter of Invar with complete calibration, end and line comparators of the highest precision; automatic dividing engine; standard weights. Rueprecht balance of the greatest precision for a load of 1000 grams, with reversing attachments, precision balances for 200 grams and for 5 grams; Riefler standard clock in vacuum case, and Riefler secondary clock, break-circuit chronometer; two precision cathetometers with two telescopes; harmonic analyzer; a large collection of tuning forks and other acoustic apparatus; apparatus for high temperature measurements; precision spectrometer with glass and quartz optical systems and polarizing and Ruben's attachments; heliostats, spectro-photometer, large Lummer-Brodhun photometer; complete set of standard resistances with oil baths and precision bridges for high and low resistances, apparatus for measuring magnetic properties of iron, large Du Bois magnet, induction coil for 50 cm. spark.

The arrangement and equipment of the lecture room has been given especial study that the experimental work might be facilitated. The table is 32 feet long and consists of two fixed sections and four movable sections. A part of the table is a pier, and a passage



Third Floor Plan, Rockefeller Physical Laboratory,
Case School of Applied Science.

can be opened through the center. There are electric connections for 500, 220 and 110 volts, alternating and direct current, and many connections for lower voltages; there are three rheostats for controlling currents of 30 and of 50 amperes at 110 volts, which can be reduced at pleasure to currents of a fraction of an ampere and a fraction of a volt. There are ample supplies of gas, hot and cold water, steam, air, etc. The artificial lights in the room, and the window shades are controlled from the lecture table. Three projection outfits are provided; one for ordinary slide projection, one with optical equipment of the largest size for all kinds of lantern demonstrations, with optical bench, microscope, spectroscope and polariscope attachments; while the third lantern is the largest size of projector for opaque objects.

(Demonstrations were made of some of the conveniences of the lecture table, and the opaque projector was used to show the floor plans which are reproduced herewith. The entire building was then thrown open for informal inspection.)

THE SIX-DAY SYSTEM AT THE UNIVERSITY OF MINNESOTA.

BY FRANK H. CONSTANT,
Professor of Structural Engineering, University of Minnesota.

Prior to September, 1904, Monday was the nominal weekly holiday at the University of Minnesota in the College of Science, Literature and Arts and in the College of Engineering. No recitations or lectures were held on this day, but the difficulties of the program committee and of the individual instructors in finding hours for their work gradually opened up this day for laboratory, shop and drawing work. Saturday afternoon, although nominally a work day, was actually a half holiday for most students, and owing to the attraction of athletic games generally held at this time, few professors were willing to have their work scheduled for that time. Recitative and lecture work was thus practically concentrated into four and a half days, with a certain amount of laboratory and shop work overflowing into the sixth day.

The movement to utilize all six working days was originated in the College of Science, Literature and Arts. In that college the change was a momentous one and was accompanied by two equally important innovations which in the minds of most people are linked with the six-day movement, viz:

(*a*) To change most subjects from four to three hours per week and to require each student to carry five subjects instead of four, the total number of hours for the four years being the same as before.

(*b*) To introduce a more purely elective system modified by a series of sequences.

After three years the system has its adherents and opponents in that college, but upon examination it is found that generally the opposition is centered in the associated three-hour elective system rather than upon the six-day arrangement per se. The principal argument advanced against the latter will be given in its place.

The movement came at a time when the rapidly growing number of students in the College of Engineering, and the increasing number of sections without additional housing for them, made the work of the program committee exceedingly difficult. This college fell in line with the academic department, and, so far as I know, during the three years since its adoption there has been no opposition to it. The accompanying plates give the programs for the College of Engineering for the second semester of 1903–04, the year preceding the adoption of the six-day system, and for the second semester of the year just completed, respectively. In the latter it will be noticed that the bulk of the lecture work still comes between Tuesday and Saturday, inclusive; while, with the exception of mathematics and physics, Monday is still largely a laboratory, shop and drawing day. But a more generous amount of the latter work is now put into that day than formerly, and the program committee has the privilege of putting in as much more as it deems necessary or advisable. It will also be noticed that Saturday afternoon is kept open in both schemes. A study of last semester's program will

bring out the significant fact that were it now attempted to concentrate all of the student work into four and a half days, assuming class rooms and instructors enough for such congestion, in nearly every such case each student would be attending classes during practically all of the working hours of the week. In four and a half days there are thirty-six available class hours. The schedule shows the following number of required class-hours for each of the four years of the civil engineering section: Freshman, 36; sophomore, 36; junior, 34; senior, 33.

The schedules for the other departments, with the larger amounts of shopwork, are just as bad. The writer is aware that some of this work may be thrown into the summer, and that the number of hours should, in the judgment of some, be reduced. Each of these is a separate question which this paper will not attempt to discuss. As a matter of fact, the college has shown no disposition to reduce the number of student-hours, and accepting this as fixed for the present, the problem has been to properly provide for them. While the above schedule seems heavy, it must be remembered that much of the work of the college is in the double-hour periods of the laboratories, shops and drawing rooms, requiring many actual hours of attendance per week. The actual number of credit-hours ranges from twenty to twenty-two per week.*

The main arguments in favor of the six-day system, at least in the College of Engineering, are as follows:

1. Greater flexibility and ease in program making. To further this end still more the academic college

* Since the above was written a strong movement has been initiated to reduce the number of credit hours to 20 or less.

adopted the three-hour unit (an exact divisor of the six working days), and the elective system, which allows the student much latitude in the arrangement of his program. But in the College of Engineering all of the courses are prescribed and the program committee must provide complete schedules, free from conflicts, for all regular students, and with a maximum of thirty-six out of a possible forty-four hours to provide for, the task, even upon the six-day basis, is not an easy one. At Minnesota this difficulty alone is considered sufficient justification for the adoption of the system.

2. Economy of class-room space. The rapidly increasing growth of the college brought with it increasing numbers of sections without a corresponding expansion of the physical housing. For some time the college has felt cramped in its present quarters and it became a matter of imperative necessity to increase the number of working hours per class-room. The burning of the old main building of the College of Science, Literature and Arts several years ago, and the consequent overflow of academic classes into the other buildings on the campus, including the engineering buildings, pending the construction of a new main building, rendered the situation more acute. This condition of acute crowding generally occurs periodically in a rapidly growing institution until it is temporarily relieved by the construction of new buildings which in turn are soon filled up. For the reason that money is best expended in equipment, instructors and adequate salaries, rather than in brick and stone; for the reason that buildings bring greatly

increased unproductive expenses, such as janitor service, lighting and heating, insurance, furnishing and similar fixed charges, thus becoming a heavy drain upon the income of the university; and for the additional reason that campus space is often limited and cannot be increased indefinitely without great cost, the question of economy of space becomes an important one and, in general, true economy would put each room into as frequent service as is otherwise practicable during all of the six working days of the week.

3. Student effort in an engineering college can be made more effective when applied steadily during six days than when concentrated into four and a half days. This reason may or may not be of weight in the academic courses, where it is generally considered desirable that students should have periods of freedom from class-room attendance for individual development along other lines of collegiate activity or for catching up in assigned work. Even in this case it may be urged that when the free day is largely spent in the library for reference reading, the latter may very easily become congested. The work of the engineering college, however, is best done under steady pressure. There is a certain amount of technical ground which must be covered and the compassing of this prescribed work leaves little opportunity in a four years' course for side browsing. Much of this work, involving as it does the elements of experience and judgment, must be done under the eye of the instructor and more frequent personal contact of student with instructor is essential than in the academic department. As the advancing work becomes

more and more technical, this relation assumes in the upper classes many of the characteristics of chief to assistant, as found in an actual engineering organization. As much of the work of the engineering student must be done under direction, or at least in frequent consultation with his chief, the instructor, he will make better progress when he can utilize all of the working days of the week in this manner. In this way he is disciplined for the actual conditions of his professional life and the step from class-room to engineering office is not great.

It has been stated above that so far as the writer is aware there has been no real opposition to the system in this college. In the academic college it has been urged that the loss of the Monday holiday necessitates Sunday preparation and poor recitations on Monday. In the engineering college this condition is met by still leaving Monday largely a laboratory day. It has also been objected that there is no convenient day for janitors and scrub women to clean the rooms. I suspect this is an administrative detail easy to overcome. There has been no complaint that instructors are deprived of a free day for their own work for the reason that each instructor can arrange his work to leave an off day if he so wishes and from an administrative standpoint it is a decided advantage to have a majority of the teaching force always on hand.

On the whole the six-day system has proved so satisfactory in the College of Engineering at Minnesota that it will in all probability remain fixed.

(For discussion, see page 206.)

FRESHMAN ENGINEERS 1903 2 1904

Day	Hour	A Civil	B Mech. & Electr.	C Mech. & Electr.	D Mech. & Electr.
MONDAY	1			Shop	
	2			Shop	
	3			Shop	
	4			Shop	
	5		Shop		
	6		Shop		
	7		Shop		
	8		Shop		
TUESDAY	1	Mathematics	Shop		Drawing
	2	English	English	Mathematics	Drawing
	3	Des. Geometry	Mathematics	English	English
	4		Des. Geometry	Shop	Mathematics
	5	Qual. Analysis		Qual. Analysis	
	6	Qual. Analysis		Qual. Analysis	
	7	Surveying	Qual. Analysis	Shop	Qual. Analysis
	8	Surveying	Qual. Analysis	Shop	Qual. Analysis
WEDNESDAY	1	Mathematics	Drawing	Des. Geometry	
	2	English	Drawing	Mathematics	Des. Geometry
	3	Surveying	Mathematics	English	English
	4	Surveying			Mathematics
	5	Qual. Analysis		Qual. Analysis	
	6	Qual. Analysis	English	Qual. Analysis	Shop
	7	Drawing	Qual. Analysis	Shop	Qual. Analysis
	8	Drawing	Qual. Analysis	Shop	Qual. Analysis
THURSDAY	1	Mathematics		Des. Geometry	Drawing
	2	English	English	Mathematics	Drawing
	3	Surveying	Mathematics	English	English
	4	Surveying	Des. Geometry		Mathematics
	5	Qual. Analysis		Qual. Analysis	Shop
	6	Qual. Analysis		Qual. Analysis	Shop
	7		Qual. Analysis		Qual. Analysis
	8		Qual. Analysis		Qual. Analysis
FRIDAY	1	Des. Geometry	Shop	Drawing	Mathematics
	2		Shop	Drawing	English
	3	Surveying	Shop	English	Des. Geometry
	4	Surveying	Shop		
	5	Qual. Analysis		Qual. Analysis	Shop
	6	Qual. Analysis		Qual. Analysis	Shop
	7	Drawing	Qual. Analysis		Qual. Analysis
	8	Drawing	Qual. Analysis		Qual. Analysis
SAT.	1	Mathematics	English	Drawing	Shop
	2	English	Mathematics	Drawing	Shop
	3		Drawing	Mathematics	Shop
	4		Drawing		Shop

Chapel Exercises, 10:25–10:40.
Drill, Wednesday 1:10–1:50; Saturday 1:10–2:20.

SOPHOMORE ENGINEERS 1903 2 1904

		D	C	B	A
MONDAY	1	Shop 1	Shop		Topog.
	2	Shop 1	Shop		Topog.
	3	Shop 1 Phy. Lab. 2	Shop		Topog.
	4	Shop 1 Phy. Lab. 2	Shop		Topog.
	5	Phy. Lab. 1 Shop 2		Kinematics	
	6	Phy. Lab. 1 Shop 2		Kinematics	
	7	Shop 2		Kinematics	
	8	Shop 2		Kinematics	
TUESDAY	1		Mechanism	Mechanism	Mathematics
	2	Mechanism		Mathematics	Topog.
	3	Physics	Physics	Physics	Physics
	4		Mathematics		
	5		Kinematics	Shop	
	6	Mathematics	Kinematics	Shop	Highways
	7	Drawing	Kinematics	Shop	Phys. Lab. 1
	8	Drawing	Kinematics	Shop	Phys. Lab. 1
WEDNESDAY	1	Forge Lect.	Drawing	Physics	Mathematics
	2		Drawing	Mathematics	Physics
	3	Physics	Mathematics	Drawing	
	4	Mathematics	Physics	Drawing	
	5	Drawing	Shop	Phys. Lab. 2	
	6	Drawing	Shop	Phys. Lab. 2	Highways
	7		Shop		Topog.
	8		Shop		Topog.
THURSDAY	1		Mechanism	Mechanism	Topog.
	2	Mechanism			Topog.
	3	Physics	Physics	Physics	Physics
	4	Mathematics	Mathematics	Mathematics	Mathematics
	5	Shop	Phys. Lab. 1		
	6	Shop	Phys. Lab. 1		Astronomy
	7	Shop		Phys. Lab. 1	Drawing
	8	Shop		Phys. Lab. 1	Drawing
FRIDAY	1		Mechanism	Mechanism	Mathematics
	2	Mechanism		Mathematics	Topog.
	3		Mathematics		Drawing
	4	Mathematics			Drawing
	5	Kinematics	Drawing	Shop	
	6	Kinematics	Drawing	Shop	Astronomy
	7	Kinematics	Phys. Lab. 2	Shop	
	8	Kinematics	Phys. Lab. 2	Shop	
SAT.	1	Shop Lect.	Shop Lect.	Shop Lect.	Mathematics
	2			Mathematics	Topog.
	3		Mathematics	Drawing	Phys. Lab. 2
	4	Mathematics		Drawing	Phys. Lab. 2

Chapel 10:25?10:40.
Drill, Wednesday 1:10–1:50; Saturday 1:10–2:20.

JUNIOR ENGINEERS 1903 2 1904

Day	Hour	A Civil	B Mechanical	C Electrical	D Electrical
MONDAY	1	Stresses	Mech. Lab.	Mach. Des.*	Elect. Des.*
	2	Stresses	Mech. Lab.	Mach. Des.*	Elect. Des.*
	3	Phys. Lab. 1	Mech. Lab.	Mach. Des.*	Mach. Des.*
	4	Phys. Lab. 1	Mech. Lab.	Mach. Des.*	Mach. Des.*
	5		Elect. Lab.	Mech. Lab.	Phys. Lab. 1
	6		Elect. Lab.	Mech. Lab.	Phys. Lab. 1
	7		Elect. Lab.	Mech. Lab.	
	8		Elect. Lab.	Mech. Lab.	
TUESDAY	1	Mechanics	Mechanics	Mechanics	Mechanics
	2	Geology	Dyn. and Motors	Dyn. and Motors	Dyn. and Motors
	3	Str. Details		Mach. Des.	Mach. Des.
	4	Str. Details		Mach. Des.	Mach. Des.
	5	Phys. Lab. 2	Phys. Lab. 2		Elect. Lab.
	6	Phys. Lab. 2	Phys. Lab. 2		Elect. Lab.
	7	Railroads			Elect. Lab.
	8	Railroads			Elect. Lab.
WEDNESDAY	1	Mechanics			Mechanics
	2	Physics	Physics	Physics	Physics
	3	Stresses	Mechanics	Mechanics	Steam Engines
	4	Stresses	Steam Engines	Steam Engines	
	5	Str. Details	Mach. Des.	Phys. Lab. 1	Elect. Lab.
	6	Str. Details	Mach. Des.	Phys. Lab. 1	Elect. Lab.
	7		Mach. Des.	Elect. Lab.	Mach. Des.
	8		Mach. Des.	Elect. Lab.	Mach. Des.
THURSDAY	1	Mechanics			Mechanics
	2	Geology	Dyn. and Motors	Dyn. and Motors	Dyn. and Motors
	3		Mechanics	Mechanics	Elect. Des.*
	4	Stresses	Mach. Des.	Mach. Des.	Mach. Des.*
	5		Mach. Des.	Elect. Lab.	Mech. Lab.
	6		Mach. Des.	Elect. Lab.	Mech. Lab.
	7	Phys. Lab. 3	Phys. Lab. 3	Elect. Lab.	Mech. Lab.
	8	Phys. Lab. 3	Phys. Lab. 3	Elect. Lab.	Mech. Lab.
FRIDAY	1	Mechanics			Mechanics
	2	Physics	Physics	Physics	Physics
	3	Str. Details	Mechanics	Mechanics	Steam Engines
	4	Str. Details	Steam Engines	Steam Engines	
	5	Railroads	Elect. Lab.	Phys. Lab. 2	Phys. Lab. 2
	6	Railroads	Elect. Lab.	Phys. Lab. 2	Phys. Lab. 2
	7	Railroads	Phys. Lab. 1	Elect. Des.*	Elect. Des.*
	8	Railroads	Phys. Lab. 1	Elect. Des.*	Elect. Des.*
SAT.	1		Mechanics	Mechanics	
	2	Geology	Dyn. and Motors	Dyn. and Motors	Dyn. and Motors
	3	Mechanics		Elect. Des.*	Mechanics
	4			Elect. Des.*	

Chapel Exercises, 10:25–10:40.

* Electrical Design last half of the semester.

SENIOR ENGINEERS 1903 2 1904

Day	Hour	Civil	Mechanical	Electrical
MONDAY	1			
	2			
	3			
	4			
	5			
	6			
	7			
	8			
TUESDAY	1	Str. Des.		
	2	Str. Des.	Thermo.	
	3	Geodesy.		Lab. (a) Des. (bc)
	4			Lab. (a) Des. (bc)
	5	San. Eng.	Mach. Des.	Lab. (a) Des. (bc)
	6	San. Eng.	Mach. Des.	Lab. (a) Des. (bc)
	7	Least Sqs.	Mach. Des.	Lab. (a) Des. (bc)
	8		Mach. Des.	Lab. (a) Des. (bc)
WEDNESDAY	1	Str. Des.	Mech. Lab.	Elec. Eng.
	2	Str. Des.	Mech. Lab.	Alt. Cur.
	3	Geodesy	Mech. Lab.	Lab. (b) Des. (a)
	4		Mech. Lab.	Lab. (b) Des. (a)
	5	San. Eng.	Mech. Lab.	Lab. (b) Des. (a)
	6	San. Eng.	Mech. Lab.	Lab. (b) Des. (a)
	7	Least Sqs.	Mech. Lab.	Lab. (b) Des. (a)
	8		Mech. Lab.	Lab. (b) Des. (a)
THURSDAY	1	Cont. and Spec's	Cont. and Spec's	Cont. and Spec's
	2	Str. Des.	Thermo.	Alt. Cur.
	3	Str. Des.		
	4	Pol. Sci.	Pol. Sci.	Pol. Sci.
	5	San. Eng.	Mach. Des.	Lab (c)
	6	San. Eng.	Mach. Des.	Lab (c)
	7		Mach. Des.	Lab (c)
	8		Mach. Des.	Lab (c)
FRIDAY	1	Cont. and Spec's	Cont. and Spec's	Cont. and Spec's
	2		Thermo.	Alt. Cur.
	3	Geodesy		Elec. Eng.
	4	Pol. Sci.	Pol. Sci.	Pol. Sci.
	5	Str. Des.		Lab (c)
	6	Str. Des.		Lab (c)
	7	Str. Des.		
	8	Str. Des.		
SAT.	1		Mech. Eng.	
	2		Mech. Eng.	
	3		Mech. Eng.	
	4		Mech. Eng.	

Chapel Exercises, 10:25–10:40.

2nd

College of Engineering

1906-1907

FRESHMAN SCHEDULE

		A	B	C	D	E
MONDAY	1	Mathematics	....	Chemistry	....	Chemistry
	2	....	Mathematics	Chemistry	Shop	Chemistry
	3	Drawing	Drawing	....	Shop	Mathematics
	4	Drawing	Drawing	....	Shop	....
	5	Surveying	Surveying	Mathematics	....	Drawing
	6	Surveying	Surveying	Shop	Mathematics	Drawing
	7	Surveying	Surveying	Shop	....	Drawing
	8	Surveying	Surveying	Shop	....	Drawing
TUESDAY	1	Mathematics	English	Chemistry	Shop	Chemistry
	2	English	Mathematics	Chemistry	Shop	Chemistry
	3	Surveying	Surveying	Des. Geom.	Shop	Mathematics
	4	Surveying	Surveying	English	Des. Geom.	English
	5	Chemistry	Chemistry	Mathematics	....	Shop
	6	Chemistry	Chemistry	....	Mathematics	Shop
	7	Drawing	Drawing	....	Chemistry	Shop
	8	Drawing	Drawing	....	Chemistry	....
WEDNESDAY	1	Mathematics	Des. Geom.	English	Drawing	....
	2	Des. Geom.	Mathematics	Shop	Drawing	English
	3	English	English	Shop	English	Mathematics
	4	....	....	Shop	....	Des. Geom.
	5	....	....	Mathematics	....	....
	6	....	....	....	Mathematics	....
	7	Drill	Drill	Drill	Drill	Drill
	8	Drill	Drill	Drill	Drill	Drill
THURSDAY	1	Mathematics	English	Chemistry	Drawing	Chemistry
	2	English	Mathematics	Chemistry	Drawing	Chemistry
	3	Surveying	Surveying	Des. Geom.	English	Mathematics
	4	Surveying	Surveying	....	Des. Geom.	....
	5	Chemistry	Chemistry	Mathematics	....	Shop
	6	Chemistry	Chemistry	Drawing	Mathematics	Shop
	7	....	....	Drawing	Chemistry	Shop
	8	....	....	....	Chemistry	....
FRIDAY	1	Mathematics	Des. Geom.	English	Drawing	English
	2	Des. Geom.	Mathematics	Shop	Drawing	....
	3	English	English	Shop	English	Mathematics
	4	....	....	Shop	....	Des. Geom.
	5	Drawing	Drawing	Mathematics	....	Shop
	6	Drawing	Drawing	....	Mathematics	Shop
	7	Chemistry	Chemistry	Drawing	Chemistry	Shop
	8	Chemistry	Chemistry	Drawing	Chemistry	....
SATURDAY	1	[Surveying]	[Surveying]	....	English	Drawing
	2	[Surveying]	[Surveying]	English	Shop	Drawing
	3	Surveying	Surveying	Drawing	Shop	English
	4	Surveying	Surveying	Drawing	Shop	....
	5	Drill	Drill	Drill	Drill	Drill
	6					
	7					
	8					

Chapel Exercises, 10:25–10:40.

2nd College of Engineering

1906-1907

SOPHOMORE SCHEDULE

Day	Hour	A Civil	B Mechanical and Electrical	C Mechanical and Electrical	D Mechanical and Electrical
MONDAY	1	Physics	....	Drawing	Shop
	2	Topography	Physics	Drawing	Shop
	3	Topography	Phys. Lab. (1)	....	Shop
	4	Topography	Phys. Lab. (1)	Physics	Shop
	5	P L (1) Chm (2)*	Kinematics	Shop	Drawing
	6	P L (1) Chm (2)*	Kinematics	Shop	Drawing
	7	Chemistry (2)*	Kinematics	Shop	....
	8	Chemistry (2)*	Kinematics	Shop	....
TUESDAY	1	Topography	Mechanism (1)	Mathematics	Mechanism
	2	Mathematics	Mechanism (2)	Mechanism	Mathematics
	3	Physics	Physics	Physics	Physics
	4	Highways†	Mathematics	Shop Lect.	Shop Lect. (2)
	5	Chemistry (2)*	Shop	Kinematics	Phys. Lab. (1)
	6	Ast (1) Chm (2)*	Shop	Kinematics	Phys. Lab. (1)
	7	Chemistry (2)*	Shop	Kinematics	....
	8	Chemistry (2)*	Shop	Kinematics	....
WEDNESDAY	1	Mathematics	....	Physics	Physics
	2	Physics	....	....	Mathematics
	3	Drawing	Mathematics	....	Shop
	4	Drawing	Physics	Mathematics	Shop
	5	Highways†	Drawing	Phys. Lab. (2)	Shop
	6	Astronomy (1)*	Drawing	Phys. Lab. (2)	Shop
	7	Drill	Drill	Drill	Drill
	8	Drill	Drill	Drill	Drill
THURSDAY	1	Mathematics	Mechanism (1)	....	Mechanism
	2	Topography	Mechanism (2)	Mechanism	Mathematics
	3	Physics	Physics	Physics	Physics
	4	Highways†	Mathematics	Mathematics	....
	5	....	Shop	Phys. Lab. (1)	Drawing
	6	Astronomy (1)*	Shop	Phys. Lab. (1)	Drawing
	7	Drawing	Shop	....	....
	8	Drawing	Shop	....	....
FRIDAY	1	Topography	Forge Lect.	Mathematics	Physics
	2	Topography	Physics	Physics	Mathematics
	3	Mathematics	Shop Lect.	Drawing	Phys. Lab. (2)
	4	Physics	Mathematics	Drawing	P L (2) S L (1)
	5	Highways†	Phys. Lab. (2)	Shop	Kinematics
	6	Astronomy (1)*	Phys. Lab. (2)	Shop	Kinematics
	7	Phys. Lab. (2)	Drawing	Shop	Kinematics
	8	Phys. Lab. (2)	Drawing	Shop	Kinematics
SATURDAY	1	Topography	Mathematics	....	Physics
	2	Topography	Mechanism (2)	Mechanism	Mathematics
	3	Topography	Mechanism (1)	Mathematics	Mechanism
	4	Mathematics	....	....	....
	5	Drill	Drill	Drill	Drill
	6				
	7				
	8				

Chapel Exercises, 10:25–10:40.

* Astronomy and Chemistry first half of semester.

† Highways last half of semester.

2nd College of Engineering

1906-1907

JUNIOR SCHEDULE

Day	Hour	A Civil	B Mechanical	C Electrical	D Electrical
MONDAY	1	....	Mech. Lab.	Mach. Des.*	Mach. Des.
	2	....	Mech. Lab.	Mach. Des.*	Mach. Des.
	3	....	Mech. Lab.	Mach. Des.*	Mach. Des.
	4	....	Mech. Lab.	Mach. Des.*	Mach. Des.
	5	Hyd. Lab.	F. & G. Anal.	....	Elec. Des.*
	6	Hyd. Lab.	F. & G. Anal.	....	Elec. Des.*
	7	Hyd. Lab.	F. & G. Anal.	....	Elec. Des.*
	8	Hyd. Lab.	....	....	Elec. Des.*
TUESDAY	1	Mechanics	Mechanics	Mechanics	Mechanics
	2	Geology	....	....	....
	3	St. Det. (1)	Gas Engines	Mach. Des.	Mach. Des.
	4	St. Det. (1)	....	Mach. Des.	Mach. Des.
	5	R. R.	F. & G. Anal.	Elec. Lab.	Elec. Des.*
	6	R. R.	F. & G. Anal.	Elec. Lab.	Elec. Des.*
	7	R. R.	F. & G. Anal.	Elec. Lab.	Elec. Des.*
	8	R. R.	....	....	Elec. Des.*
WEDNESDAY	1	....	....	Dyn. & Mot.	Dyn. & Mot.
	2	R. R.	....	Mechanics	Mechanics
	3	Mechanics	Mechanics	....	....
	4	Stresses	St. Engines	St. Engines	St. Engines
	5	S.Dts. (1) Biol. (2)	Mach. Des.	Elec. Lab.	Mech. Lab.
	6	S.Dts. (1) Biol. (2)	Mach. Des.	Elec. Lab.	Mech. Lab.
	7	S.Dts. (1) Biol. (2)	Mach. Des.	Elec. Lab.	Mech. Lab.
	8	S. Dts. (1)	Mach. Des.	....	Mech. Lab.
THURSDAY	1	Mechanics	Mechanics	Dyn. & Mot.	Dyn. & Mot.
	2	Geology	St. Engines	St. Engines	St. Engines
	3	Stresses	....	Mechanics	Mechanics
	4	Stresses	Mach. Des.	Mach. Des.	Mach. Des.
	5	R. R.	Mach. Des.	Elec. Des.*	Elec. Lab.
	6	R. R.	Mach. Des.	Elec. Des.*	Elec. Lab.
	7	R. R.	....	Elec. Des.*	Elec. Lab.
	8	R. R.	....	Elec. Des.*	....
FRIDAY	1	Mechanics	Mechanics	Dyn. & Mot.	Dyn. & Mot.
	2	....	Gas Engines	Mechanics	Mechanics
	3	R. R.	St. Engines	St. Engines	St. Engines
	4	....	....	....	....
	5	Biology (2)	....	Mech. Lab.	Elec. Lab.
	6	Biology (2)	....	Mech. Lab.	Elec. Lab.
	7	Biology (2)	....	Mech. Lab.	Elec. Lab.
	8	....	....	Mech. Lab.	....
SATURDAY	1	Mechanics	Mechanics	....	....
	2	Geology	Mech. Lab.	Dyn. & Mot.	Dyn. & Mot.
	3	Stresses	Mech. Lab.	Mechanics	Mechanics
	4	Stresses	Mech. Lab.	[Elec. Lab.]	[Elec. Lab.]
	5		Mech. Lab.		
	6				
	7				
	8				

Chapel Exercises, 10:25–10:40.

(1) Civil Engineers.

(2) Municipal Engineers.

* Electrical Design last half of semester.

2nd **College of Engineering**

1906-1907

SENIOR SCHEDULE

Day	Hour	A Civil	B Mechanical	C Electrical
MONDAY	1	Thesis	Thesis	Thesis
	2	Thesis	Thesis	Thesis
	3	Thesis	Thesis	Thesis
	4	Thesis	Thesis	Thesis
	5	Thesis	Thesis	Thesis
	6	Thesis	Thesis	Thesis
	7	Thesis	Thesis	Thesis
	8	Thesis	Thesis	Thesis
TUESDAY	1	Conc. or Geod.	....	Alt. Cur.
	2	St. Des.	S. Turbines	....
	3	St. Des.	C. A. or Refrig.*	Elec. Eng.
	4	Pol. Sci.	Pol. Sci.	Pol. Sci.
	5	San. Eng.	Mach. Des.	....
	6	San. Eng.	Mach. Des.	....
	7	L. Sq.* Bact.	Mach. Des.	....
	8	Bacteriology	Mach. Des.	....
WEDNESDAY	1	St. Des.	Mech. Lab.	Alt. Cur.
	2	St. Des.	Mech. Lab.	Elec. Eng.
	3	Conc. or Geod.	Mech. Lab.	Lab. (b) Des. (a)
	4	Conc. or Geod.	Mech. Lab.	Lab. (b) Des. (a)
	5	San. Eng.	Mech. Lab.	Lab. (b) Des. (a)
	6	San. Eng.	Mech. Lab.	Lab. (b) Des. (a)
	7	L. Sq. or S. E.*	Mech. Lab.	Lab. (b) Des. (a)
	8	San. Eng.*	Mech. Lab.	Lab. (b) Des. (a)
THURSDAY	1	St. Des.	....	Alt. Cur.
	2	St. Des.	S. Turbines	Elec. Eng.
	3	Cont. & Spec.	Cont. & Spec.	Cont. & Spec.
	4	Pol. Sci.	Pol. Sci.	Pol. Sci.
	5	San. Eng.	Mach. Des.	....
	6	San. Eng.	Mach. Des.	....
	7	San. Eng.*	Mach. Des.	....
	8	San. Eng.*	Mach. Des.	....
FRIDAY	1	....	....	Elec. Eng.
	2	Cont. & Spec.	Cont. & Spec.	Cont. & Spec.
	3	Bacteriology	....	Lab. (a) Des. (b)
	4	Bacteriology	....	Lab. (a) Des. (b)
	5	St. Des. Bact.	Elective	Lab. (a) Des. (b)
	6	St. Des. Bact.	Elective	Lab. (a) Des. (b)
	7	St. Des. Bact.	Elective	Lab. (a) Des. (b)
	8	St. Des. Bact.	Elective	Lab. (a) Des. (b)
SATURDAY	1	Conc. or Geod.	Mech. Eng.	
	2	Conc. or Geod.	Mech. Eng.	
	3		Mech. Eng.	
	4		Mech. Eng.	
	5			
	6			
	7			
	8			

Chapel Exercises, 10:25–10:40.

Bacteriology for Municipal Engineers.

* Elective.

THE WORK OF THE FRESHMAN AND SOPHOMORE YEARS OF ENGINEERING COURSES.

BY FRED A. FISH,
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Some three years ago the engineering faculty of the Iowa State College began the work of revising its engineering courses of study. This revision was undertaken mainly for two reasons: first, because it was desired to raise the standard of admission; second, because it was felt that the curriculum was overcrowded at some points and that a better balance could be secured by a rearrangement and perhaps by a reduction of the amount of work required in some studies. It was further recognized that some attention should be given to the subjects of governmental and business economy. Up to the present time, the work for only the freshman and sophomore years has been revised; but the courses for the remaining two years will be revised during the coming year.

As a preliminary to the determination of the courses, it was decided to obtain and tabulate what other institutions were doing. An effort was made to reduce the material found in the various college catalogs to a common basis by figuring the total number of credit hours required in each subject. This was rendered somewhat difficult in some cases by the fact that the exact number of working weeks per term or semester was not given, and also by the lack of knowledge as to how many laboratory, shop,

or field hours were counted as one credit hour. The results were considered satisfactory, however, in the majority of cases and are set forth in Table I. The figures given refer to the actual number of class-room or laboratory hours devoted to the subject. It should be remarked that the figures given in this table may not be in all respects fairly comparative of the actual amount of work done, inasmuch as the practice varies relative to the amount of time expected to be used in preparation for recitations, and the length of laboratory periods may not be correctly taken. In cases where the length of laboratory periods was not stated, three hours was assumed. Military drill, gymnasium work, and athletics are not considered, either in the table or in the discussion.

In order to induce discussion on certain points, some of the questions which confronted the Revision Committee at Iowa State College and the solutions at which the committee arrived will be stated.

(*a*) What should be the number of credit-hours per week? This question involves two others, viz: how much time should be required in preparing for a recitation and how many hours of laboratory work should be required for one hour of credit? These questions were answered by deciding that one credit hour should mean one hour of recitation with two hours of preparation, or three hours of laboratory work. Then, assuming fifty-four actual hours per week as a reasonable number, the number of credit hours per week was settled upon as eighteen. Reference to the last column of Table I. shows that this figure is common.

(*b*) In what studies should the work be reduced? Previous to this time the number of semester-hours for the two years had been seventy-nine. Solid geometry, which had been given in the freshman year, was made an entrance requirement, and the number of semester-hours in mathematics reduced thereby from twenty to nineteen. Modern language was reduced from ten to six semester-hours. Chemistry, which had previously been given in the sophomore year, was divided between the freshman and the sophomore years, and increased from ten to eleven semester-hours. Two semester-hours of history were dropped from the freshman year and are given in either the sophomore or junior year, but will make nineteen credit-hours per week for the year in which it is taken, instead of eighteen, as originally planned.

(*c*) What changes could be made so as to begin the study of mechanics in the second term sophomore year? In order to do this, elementary drawing was reduced from seven to five semester-hours, descriptive geometry, from four to two semester-hours, and three semester-hours of mechanics were added.

The changes above mentioned are those for the courses in mechanical and electrical engineering.

For the civil engineers, the chemistry was reduced to seven hours, and descriptive geometry, from five to four hours. Only two hours of mechanics were added to their course and to the course for mining engineers. Chemistry was increased from ten to fourteen semester-hours for the mining engineers, while surveying was reduced from four to two hours.

Table II. shows the courses as finally decided upon

for the two years. The figures given are the actual hours in class-room or laboratory. It should be explained that in the case of physical laboratory, only two laboratory-hours are required for one credit-hour. It should also be stated that the thirty-four technical lectures given to the freshmen are considered as introductory to the courses in which they are given. Credit for them is understood to be included in that for the other work of the course. These lectures have now been given for two years and are considered a useful addition to the work.

It may not be amiss to refer briefly to the requirements for admission to unconditional freshman classification. These requirements at Iowa State College are as follow:

English	630
History	315
Algebra, plane and solid geometry	630
Foreign language (Latin, French, German or Spanish)	180
Drawing	45
Elective	900
	2700

Expressed in semester-credits, meaning thereby a unit of five hours per week for eighteen weeks, this is the equivalent of thirty semester-credits:

English	7
History	3½
Algebra, plane and solid geometry	7
Foreign language (Latin, French, German or Spanish)	2
Drawing	½
Elective	10
Total	30

With reference to language, it should be stated that if a student presents Latin for his entrance require-

Foundry	Forge Shop	Mach. Shop	Mechanism Rec.	Mechanism Draw.	Mechanics	Materials	Mineralogy	Mach. Design	M. E.	E. E.	C. E.	Mn. E.	Total Recitations	Total Lab. Hours	Av. Hours per Week
0	0 0 0 51	0	0	0	0	0	0 0 51 102	0	0	0	0	0	1088 1088 1129 1190	968 975 1080 981	22
0	108	106	72	(?)	45	0	0	0	0	0	0	0	990	882	18
68 68 0	68 68 0	0	84 84 0	153 153 0	170 170 170	84 84 51	0	0	0	0	0 0 204m	0 0 0 102p	659 659 799	1173 1173 983	17½
→	54	270 270 0	45 45 0	(?) (?) 0	54	0	0	0	0	0	0	0	819 819 828	1269 1269 1116	19
96 96 0 0	114 114 0 0	0b	0	0	57 57 88 88	0	0	0	35j 0 0 0	0 35j 0 0	0 0 35j 0	0 0 0 35j	992 992 1018 1018	1098 1098 1015 1015	18
0	0	0	0	0	102 102 85 85	0	0 0 0 85	153 0 0 0	85k 0 0 0	0 1191 0 0	0 0 85n 0	0 0 0 51q	918 901 782 816	871 769 934 1226	18
0	90	165 165 165 0	0	0	138 138 36b	0	0 0 0 85	0	85k 85k 0 0	0	0	0 0 0 90p	928 928 928 968	915 915 898 781	19½
80f 0 0	64 64 0	144f 0 0	0	0	48	0	0	0	0	0	0	0	912 912 864	496 480 416	17
→ →	90 90 0	270 270 0	54 54 0	0 0 0	0	0	0	0	0	0	0 0 72o 0	0	755 756 845	1522 1522 1306	21½s
→	144 144 0	128 128 0	36	108 108 54	54	0	0	0	0	0	0	0	806 810 900	1118 1114 1170	17
0b 0b 0 0	72 72 0 48	72b 144b 0 0	0	0	0	0	0 0 0 30	0	0	0	0	0 0 0 306r	824 892 926 854	864 924 540 858	18
→ → —	162 0 →	342h 288h 0	0	0	0	0	0	0	0	0	0	0	882 882 900	1296 1152 1224	20
0	110	0	66	0	0	0	0	0	30k	0	0	0	1235 1235 1348	668 698 678	(?)
→ → 0	36 0 0	126 0 0	0	0	85	0	0 0 36	108i 108i 0	0	0	0	0	1084 1156 1144	839 677 761	19½
72 16 16	72 72 32	128 56 32	0	0	0	0	0	0	0	0	0	0	918 954 884	1132 1106 1232	18

; elec. lab., 51.

68.

o. Astronomy 36; highway construction, 36.
p. Geology.
q Metallurgy.
r. Metallurgical laboratory.
s. One hour credit for two hours shop or lab.

ment, his freshman work will be beginning French, German or Spanish; if he offers one of these modern languages, he will take advanced work in the language which he presents.

Referring again to Table I., it will be observed that no column is given for solid geometry; this is because it was found to be an entrance requirement for every college whose course was studied, excepting Texas.

It is interesting to note that an observation made by Professor Caldwell eight years ago in his "Comparative Study of Electrical Engineering Courses"* still holds good: namely, the rather wide variation in the amount of time devoted to English, language, shopwork, and some others; and the uniformity in the time given to mathematics and physics. At Purdue and Wisconsin, geometry has been changed from a freshman study to an entrance requirement since the time of Professor Caldwell's study; also, the beginning of the study of mechanics has been changed from the junior to the sophomore year at Cornell, Illinois, Kansas and Michigan. The figures in the last three columns of the table seem to indicate a fairly uniform practice as to the amount of time allowed for preparation for recitations. However, at Case, twenty-two credit-hours per week are required, which would indicate either that a rather shorter time is allowed for preparation, or that more actual hours of work per week are required than at the other institutions.

The writer will be glad to have pointed out to him any errors or incorrect assumptions that have been made, in order that the table may be made as nearly correct as possible.

* Proc. Soc. Pro. Eng. Ed., Vol. VII., p. 127.

TABLE II

FRESHMAN AND SOPHOMORE COURSES IN ENGINEERING AT IOWA STATE COLLEGE

Study	Freshman Hours						Sophomore Hours						Courses
	1st Sem.			2d Sem.			1st Sem.			2d Sem.			
		Lab.			Lab.			Lab.			Lab.		
	Rec.	Cr.	Act.	Rec.	Cr.	Act.	Rec.	Cr.	Act.	Rec.	Cr.	Act.	
English........	48	..	..	57	..	..	32	..	..	..	..	..	All
Algebra	60	..	..	..	..	..	..	..	..	..	..	..	"
Trigonometry	..	..	..	35	..	..	..	..	..	..	..	..	"
Anal. Geom...	..	..	..	60	..	..	30	..	..	..	..	..	"
Calculus.......	..	..	..	..	..	..	60	..	..	76	..	..	"
Language	48	..	..	57	..	..	..	..	..	..	..	..	"
Physics	..	..	..	..	..	..	64	16	32	76	19	38	"
Tech. Lecture	16	..	..	19	..	..	..	..	..	..	..	..	"
Desc. Geom...	..	..	..	19	19	114	..	..	..	..	..	..	"
Desc. Geom...	..	..	..	..	..	..	..	16	48	..	19	57	C.E.
Mech. Draw..	..	16	48	..	..	..	..	..	..	..	..	..	"
C. E. Drawing	..	16	48	..	..	..	..	16	48	..	19	57	"
Surveying	..	32	96	..	38	114	32	32	96	38	38	114	"
Chemistry	32	16	48	38	19	57	..	..	..	19	..	..	"
Mechanics	..	..	..	..	..	..	..	..	..	38	..	..	C.E. & Mn.E.
Surveying	..	..	..	..	..	..	16	16	48	19	19	57	Mn.E.
Chemistry	32	16	48	38	19	57	16	32	96	38	38	114	"
Mech. Draw..	..	32	96	..	..	..	..	16	48	..	19	57	"
Shopwork	..	32	96	..	38	114	..	..	..	..	..	..	"
Shopwork	..	32	96	..	38	114	..	32	96	..	38	114	M.E. & E.E.
Chemistry	32	16	48	38	19	57	16	32	96	38	10	30	" "
Mech. Draw..	..	32	96	..	..	..	..	16	48	..	38	114	" "
Mechanics	..	..	..	..	..	..	..	..	..	57	..	..	" "

JOINT DISCUSSION.

PROFESSOR KENYON: For the same reasons which the author gave in his paper we have come to a five and a half day basis. Our half holiday is Saturday afternoon. The year before last we had so many students with so few field instruments, we were obliged to put in a section of civil engineering students also on Saturday afternoon. By that scheme we were able to use our instruments with four sections—two morning and two afternoon sections. This arrangement was very unpopular with both the students and instructors, so we have come to the five

and a half day basis. Many of our recitations are put on a three-times-a-week basis. This brings one set of classes on Tuesday, Thursday and Saturday afternoons, but throw the Saturday afternoon work into Saturday morning. We were forced to come to this basis by consideration of room and equipment. Personally, I believe that the student who has a whole holiday instead of a half holiday will do better work, but I do not see any way out of the difficulty at Purdue at the present time.

Dean Woodward: The plan we have adopted works very satisfactorily. It is to have neither laboratory work nor recitations on Wednesday and Saturday afternoons. Those days are free for outdoor sports, etc. It works very well. Our usual number of hours is eighteen, counting three laboratory hours as one credit hour.

Professor Schuster: I think the paper stated one unit credit would be given for three hours in the laboratory. Does that mean for actual laboratory work, or laboratory work and preparation included? On the classroom basis one unit credit is given for one hour per week in the classroom. I presume that assumes two hours preparation. If a student is required to work in the laboratory three hours per week for one hour's credit, the question arises as to where he could get his time for preparation and for report.

Professor F. C. Caldwell: I have been struck in looking over the table with the great variation that still exists in the work of the first two years of the courses, but suppose the time is hardly ripe for this Society to take steps toward getting a greater degree

of uniformity in this matter. With the increasing number of students who go from one college to another, uniformity would be most desirable, and there is no good reason why it should not exist. In the later years of the course the conditions in different parts of the country may be dictated by varying requirements, but this would not have much weight during the first two years. With regard to the amount of work, I wish to speak a word for the system in vogue at Worcester Polytechnic Institute, where the number of hours is divided up among the different subjects instead of any scheme by which an artificial number of credits is allowed for each subject. Take the fifty-four hours which Professor Fish's paper seems to show to be the general consensus of opinion as to the amount of work the average student can do in a week. Divide that up and let each department call for as much of its time in attendance at the rooms of the department as it may see fit.

Dean Raymond: I wish to endorse what has been said as to the meaning of this hour-system of credit. We are forced at our school to assign credits simply to keep in conformity with the rest of the institution; but we do practically what has been stated; and I fancy most every one does. We assume fifty-four or fifty-five hours. We have a five-and-a-half-day week. We have to use Saturday forenoon. We assume that a certain amount of work is to be accomplished in each of the different subjects, and we try to accomplish it regardless of the number of hours spent. Sometimes one subject is done more rapidly than the others. The evidence of these figures shows the

meaninglessness of the system of hours of credit. If a student does his preparation in note-writing outside, he is supposed to put in a little less time in the laboratory.

PROFESSOR COOLEY: Our first year at Michigan is absolutely the same for all branches in engineering and architecture. Our second year up to two years ago was also practically the same for all branches of engineering. The differentiation began the third year. There is a very slight differentiation in the second year at the present time. We work five and a half days in a week, and there is also some evening work for men who have electives in English.

I suppose this society has considered in the past the question of extending the length of time for the courses in engineering. All this points to a very overloaded week of work, and when the course is finished we have not disposed of the subjects that should be considered before a student is graduated. I look forward with much hope when we can all come together on a five or six year course. The requirement in Michigan is now four years plus a summer session of six weeks. We will have the fifth year just as soon as we can reach it, and then we will have the sixth year just as soon as we can reach that.

Twenty-five years ago the course in engineering was four years long, and with relatively only a few of the technical subjects now required to be taught. The course then was mainly in civil engineering, now we have a large number of engineering courses, and the student must if he succeed well, have some instruction in a number of them. We all know of

numerous cases where the graduate in one course has found his field of work in another. It is idle to attempt to crowd into four years the new lines of work along with the old.

PROFESSOR WILLISTON: There seems to be a very general feeling among the members of this Society that it would be a most desirable thing if our engineering courses could be lengthened to either five or six years. We do not seem to be satisfied with the education which many of our graduates have when they leave college. There does not seem to be opportunity to give them both the general culture and the technical training which we feel they should have. These sentiments have been expressed again and again in the papers and in the discussions at the different meetings of the Society, and yet I cannot help feeling that the solution suggested of lengthening the courses is a wrong one. The ultimate cause of the evil is the large amount of time which is wasted in the boy's life between the day when he first goes to school and the day when he graduates from his engineering course. The typical American boy is apt to regard his school work largely as a joke. He tries to find how little work he can do and still keep out of trouble. The idea of trying to do it as well as he can, or to accomplish anything for its own sake, is entirely foreign to every school boy except the occasional student. This is true until he enters college or the engineering school, and even during the first year or two in college he seldom devotes himself to his work with quite the same seriousness that he does later.

Public sentiment outside of school and college is very largely responsible for this. Boys are quick to copy from their elders, and if the American public held in higher respect and esteem those who had acquired culture and training, and refused to give to others positions of importance and responsibility, boys, too, would at once feel the importance of striving to acquire the best possible education, as they would know that it was essential to success. But one of the purposes of this Society is, so far as it is possible, to help to create and establish such a general public sentiment.

I was very strongly impressed with the difference between the public sentiment in this regard in this country and in Germany last summer as I visited a number of the German schools, and saw the great contrast between the intensive work which the average German boy does during his school period, and the work which the American boy does in the American school during the same time. The German school has the same number of years from the time the boy enters the school until he enters the university or the polytechnic school that the American school has—twelve years—and they correspond very closely to our twelve years. And yet the accomplishment on the other side of the water is enormously greater than here. The difference is almost entirely that during the whole of this period of twelve years the boy is really trying to accomplish all that he can, while in this country he is too often trying to see how little he can do, without encountering severe reprimand. I feel, therefore, that it is a mistake for

the engineering schools to simply accept things as they are and say, "We will extend the age at which a young man shall begin his actual life work," and not issue a vigorous protest against the early waste of time.

The young men who graduate from our engineering schools do not start on their life work any too young to-day, and it seems to me that the step in the right direction would be to insist that the young men who in the future may enter them shall have more thorough and better preparation, so that we shall not have to do over again work that ought to have been done in the preparatory school. If the men who enter the engineering schools really had the working knowledge of arithmetic, algebra, geometry and trigonometry which they are supposed to have, and fundamental notions of physics and chemistry, and good training in English and modern languages, most of the difficulties would disappear.

DEAN KENT: I hope Professor Cooley will go ahead and establish his five or six years' school, and I hope that Professor Raymond will go ahead with his individual classes. But whether all our schools should follow their example is a different question. The question is what is our object in these engineering schools. One object is to turn out men who will be the best kind of engineers, not when they graduate, but many years later; and for such object no doubt six years would be better than four. But if the object is to take the average product of the high school and give them such an education that when they are thirty years of age they will say, "The education I

had in the technical school was right, and the education in the shop was right,'' I think for the average boy it is better to turn him out after four years and put him in a shop where he may get a two years' post-graduate course. If a good many had that training before they came to college, it would diminish our freshman classes by twenty-five per cent. And it would be a good way to eliminate the undesirable students. The four years' course is all right. They learn a lot of engineering after they get out that they would not learn if they stayed. They would not learn much more if they stayed. I should be sorry to see this Society recommend a course to go beyond four years, but I do want to see Dean Cooley go ahead with his course so we may learn from his experience what the result will be.

DEAN TURNEAURE: I cannot help feeling that some of the difficulties we discussed yesterday about teaching the boy with poor brains, and the difficulties we are talking about this morning, show that our educational system is incomplete. Is it not true that a considerable proportion of the students now in our engineering schools should be in a trade school or in an industrial school of secondary character? I hope we may some day aid the professional engineering schools by giving opportunity for a considerable proportion of the students to attend some other type of school.

PROFESSOR COOLEY: Where are the industrial schools?

PROFESSOR MAGRUDER: They are right here.

PROFESSOR COOLEY: There is no more important question in America to-day than the question of in-

dustrial education. With all the good that has resulted from the organization of labor there is mixed with it some things really bad. For instance, we find in some localities restrictions placed on the number of apprentices in a particular trade with the idea of keeping down the numbers who work in that trade that wages may be kept higher, and there is the tendency to insist on equal wages to all regardless of relative skill. It is a leveling tendency, which it seems to me can have only a pernicious result. This country is confronted with a situation which, considering our importance in the world's work, must speedily become desperate unless we awaken to a realization of the changes surrounding us.

The son is not encouraged to follow in his father's footsteps, even when he should. He seeks a different sphere of work, often with good results to be sure, but with the one conspicuous result that our industrial ranks must be filled from abroad.

One question often occurs to me, and that is, have our land-grant colleges been doing the work contemplated for them when the grants were made by our federal government? Is not there a greater and more important field of work for them outside of engineering which they one and all are teaching?

Professor Bass: A great many students who come to the University of Minnesota in the engineering college are not temperamentally fitted for an engineering education, and that fact appears during their course in the freshman year. My attention has been called to this as we are re-arranging the civil engineering course, and the change which I understand has been

made in Iowa is that of taking the surveying out of the freshman year and putting it into the sophomore year. This is something that is contemplated at the University of Minnesota. The technical work will then be out of the freshman year and not started until the sophomore year. If such a plan were adopted, it would make it possible for the student who had entered one course to change from that course to some other course of engineering, or even to a course in another college—either a professional college or the college of science, literature and arts, and still not lose the credit he had gained in his first year's work in the engineering college. Another reason for that same modification—that of beginning the professional work in the sophomore instead of the freshman year—is the gradual change in the freshman student. The freshman is very pliable and usually in a receptive mood, and he can be given during his freshman year a thorough survey of the engineering world, what his relation as an engineer will be to life, and then he will have a more intelligent choice of courses in the sophomore year, and that without losing any time by changing from one course to another. The fear of being put back a year by changing his course, does, I believe, prevent many a student from making a change which he recognizes as desirable. Then once he has gotten into the sophomore year there will be opportunity to keep his nose on the grindstone and use up some of that superabundant sophomoric energy.

DEAN WOODWARD: I think half of the troubles we suffer in carrying our students through their courses is due to our own incompetency in mapping out work

for young men. I do not think our troubles so largely arise from inefficient and faithless secondary schools. I think the secondary schools throughout the country are excellent. We cannot make our boys men. They have to grow. They have to go through the primitive period. They have to become men, and become serious just as we did by going through the lower regions of work.

We make a great mistake in differentiating our courses so early—differentiating them sometimes from the very start, sometimes at the end of a first half year, and very rarely at the end of two years. We lay out a strictly professional course along one line and as we see new material, we take in available material. I think our programs are too heavy. Progress is not measured by hours. The school that requires twenty-two hours does not necessarily give twice as much as one that requires eleven. I believe in concentration. I believe that there is too much of diffusion, too much uncertainty, too much rattle-trap work by the student who has eight or ten different subjects on his program during the week. I think we fail by undertaking too much. No wonder we want five or six years. I think we shall want twice that time after a while. I am in favor of the simpler course of study; fewer subjects and more concentrated work, and I base my observation on long experience. Of course, there is the extreme of one study a week. One man told me he was studying Latin and had sixteen recitations a week—one in mathematics and fifteen in Latin. For a man to recite three lessons a day in Latin, five days a week,

is carrying concentration to excess. In our university all the students work on the same program until the middle of the sophomore year. Then the architects and chemists go a little aside, while the civils, mechanicals and electricals continue together; and they separate at the end of the junior year.

PROFESSOR MAGRUDER: In answer to Professor Schuster's question to Professor Fish I would say that I thorougly believe that there should be a rule of every faculty permitting each professor to claim three hours per week, and no more, of the time of each of his students for each credit hour assigned, no matter whether the work be in the laboratory, or in drawing, or in recitation and the preparation therefor, or a visit of inspection to an engineering works or plant, or in any other way that the professor may see fit to use the time. He should then be held responsible for the results. This plan has been practiced in the teaching of descriptive geometry for many years and it should be extended to other subjects. With large institutions and with very crowded conditions as to buildings, and with few men in the teaching force, it may be difficult to work out a flexible schedule. Otherwise, it can be worked out without practical difficulty, if the professor is willing to give the extra time to it which it requires.

I would ask Professor Fish if he has had the figures in Table I. checked up by members of the teaching forces of the various institutions. If not, I am fearful of the accuracy of the table. We have made a similar investigation this past year, and have the figures for the course in mechanical engineering for

the whole four years for some twenty-six colleges. I am unwilling to draw any conclusions from them until the figures for each institution shall have been approved by a member of its department of mechanical engineering.

PROFESSOR C. RUSS RICHARDS: Dr. Woodward's remarks brought home to me a serious question which I have had up for some time—whether in the four years of the undergraduate course we are warranted in differentiating our work into the different branches of engineering that are now given. It seems to me in the four years of the undergraduate course there are certain basic subjects—basic to all branches of engineering—that the student should master. In our own institution we give certain specialties which to me seem of questionable value. We go into specialities, which, if a student has the proper basic perspective of the whole subject of engineering, he can bring up in his outside work. But it is almost impossible for the student to determine where he will land. He may expect to become an electrical engineer, where the opportunity may be much better to become a mechanical engineer. If a man in his four years' course is well grounded in the different basic subjects, he is apt to land on his feet wherever he lights. If he wishes to specialize, why not take an extra year and give his whole time to the work he may choose? Before he takes this specialized work he should have a year or two of post-graduate work in practical lines. Then he can go back to college with a high degree of profit. I am inclined to think if we put the six years' course into the calendar, no one will take it.

It would be a good thing if a man had the time and money. But there are few men in our institutions who have the time and money. By the time they finish a six years' course they have lost some of the best years of their lives.

Professor Bass: We like to say that the engineering profession ranks with the medical profession and that of law. If there is any justification for the present practice of medical schools and law schools for making their work entirely post-graduate or for requiring at least two years of general work or academic work before students may enter law or medical schools, then there is some justification for the same requirement for engineering schools.

There are many classes of responsible positions that could be filled by men with an engineering education, but which are not so filled at present because the engineering graduate has not been led to see the opportunities during his college course. Nearly every engineering curriculum is crowded with technical subjects which are rightly there, but to value the relative importance of these subjects and their proper relations to other activities of life is something which a broader education will help the student to do.

Professor Brackett: In our institution the mechanical, electrical and civil engineering courses are practically identical for two and a half years. At the middle of the junior year the civil engineers differentiate slightly from the mechanical and electrical engineers. The mechanical and electrical courses are identical for three years. We are satisfied with the system, and if we make further changes the courses

will probably become nearer alike than they now are.

PROFESSOR WEBB: Has any one any statistics as to what these men do after they graduate? Suppose a man is graduated in a definite engineering course, are there statistics to show whether he remains throughout his active life in that branch of the profession in which he graduated, or whether he changes to another branch or leaves the profession entirely?

DEAN KENT: I have some statistics on that. Every civil engineer graduating from our college in the last four years has remained a civil engineer. We give them all the same course in the freshman year. All of our civil engineering graduates get their positions before they leave college through the state civil service board, and they remain as civil engineers.

THE CHAIR: Your statistics are not good engineering. It takes twenty-five years to tell what engineering graduates are going to do.

DEAN COOLEY: We have forty years' data on that subject.

PROFESSOR CONSTANT: The discussion has drifted off along lines somewhat foreign to the paper which I presented. The paper was prepared at the request of the Secretary to answer a number of inquiries as to what is meant by the six-day system at Minnesota. I was not sure but that I should find that many other colleges have likewise abolished the time-honored weekly holiday and that my paper would touch upon nothing new. I am still in doubt upon this point and I regret that the discussion did not bring out more fully the general practice throughout the country. No one has stated that his college is trying to do work

in less than five and a half days, nor that it is utilizing the whole six days. With us, as I brought out in the paper, the expansion into the sixth day was inevitable and the system now seems the only logical one to use.

PROFESSOR FISH: In answer to Professor Magruder's question, I was unable to get these data checked by the authorities of the colleges because of the fact that I did not undertake the preparation of this paper until too late for correspondence. I shall be glad to be informed of anything that is incorrect. I will later take up the subject with the various colleges for the purpose of checking these figures.

I think the answer to Professor Shuster's question is to be found in the paper; nearly all of the catalogs were explicit as to the number of hours in a laboratory period; of course time put in outside of the laboratory period is not included in the figures.

With reference to Professor Raymond's remarks, I think it will be generally agreed that these figures do not tell the whole story; but I think that they may be taken in general as fairly comparative.

A COMBINED CULTURAL AND TECHNICAL ENGINEERING COURSE.

BY GEORGE R. CHATBURN,
Professor of Applied Mechanics and Machine Design, University of Nebraska.

For a number of years the writer has been trying to persuade himself that the technical engineering courses have in them the cultural value necessary and sufficient for any engineer. But up to the present time he has been unable to do so. He wishes to concede at the beginning that it is neither possible nor desirable for all engineers to be educated exactly alike. The individuality of the student should be a determining factor. Therefore it may be well eventually to generalize the technical courses and make part of the work elective. Trade schools and short courses might properly be encouraged for the benefit of those who have not the time, means, or inclination, to take a full-rounded technical course or the cultural technical course which will be outlined below.

Dr. Kent, in a recent lecture at the University of Nebraska, gave a diagram showing graphically the different schools through which, or by which, men were prepared for the various professions and trades. This diagram shows that some engineers pass through the grammar school, high school, liberal arts college, and professional college. Others go directly, and no doubt these are in the majority, from the high school to the professional college, and still others from the high school immediately to practical engineering,

others through a correspondence school, a trade school or a shop apprenticeship course. All these highways to engineering are legitimate, are necessary to satisfy the demands of the busy present-day conditions. But it is the object of this paper to pay especial attention to a route which gives the student the benefit of a very high scholastic attainment, the benefit of the liberal arts college and the professional or technical college, but by taking them in combination instead of in series a marked saving in time is possible.

The ideal education of an engineer is one that fits him as near as may be possible for his life work: first, by a thorough training in the fundamentals of his profession; second, by training in a few purely technical subjects of his special line of engineering; third, by a training in some of the cultural, social and physical subjects not, or at least but remotely, related to engineering. The first and second divisions give depth, the third breadth. While great depth necessitates some breadth, and great breadth some depth, if there is to be much substantial training extremes of depth and breadth are not desirable, but somewhere between these two lies the ideal.

We are just passing through the age of commercialism. Everything has been measured by its commercial value. The value of an education is to a great extent, and perhaps rightly, so measured to-day. Schools and colleges have dwelt largely upon that phase of the matter and have put into their courses only those subjects which will bring immediate returns in dollars and cents and have largely neglected the social and esthetic side of humanity. Utility has

been the criterion which determines whether or not a subject should be placed in the curriculum; and, under this criterion, it has been argued that only technical subjects are necessary. But isn't it a fact that a person is likely to use advantageously to himself any subject with which he is familiar? Will he not invent uses for such subjects? Isn't the test of ones learning the power to use it? The writer would boldly state that no branch of study is entirely useless to an engineer providing he has mastered that branch. Engineering in its true sense is a very broad profession and should also be a learned profession. Music may be as far from an engineers's requirements as any subject; but is it not conceivable that, not to mention its usefulness as a recreation, it might often help an engineer socially and thus aid him professionally?

But everything of potential value can not be put into the curriculum, neither is it advisable for the student to give equal weight to all branches now in the curriculum, nor to devote to purely cultural and broadening subjects as much energy as he gives to technical and deepening subjects. Before the days of saw and planing mills and when heavy framing was in vogue, the adz was a most useful tool to the carpenter, now not one house carpenter in ten has the adz in his kit because it does not pay to carry it about although it might sometimes be useful. A building is not designed to resist a tornado because the chance of its being destroyed by a tornado is so small that it will not pay. But notwithstanding this it might be interesting to a carpenter to know that once the adz was a very useful tool, and to some of

the early builders the most useful; it might be beneficial to know that the force of a tornado is not irresistible and that buildings can be made to withstand it. The first illustration is historical and therefore cultural, the second is technical but likewise cultural. Again it is certainly very satisfying to be able to understand and converse about the arts and sciences, the great events in history and the beauties and sublimities of the world's literature. It is not depth but breadth of knowledge that gives a student a wider horizon, a greater outlook upon life. Something which will encourage originality, individuality and boldness of attack, but discourage narrowness, self-conceit and self-sufficiency.

But granting that breadth of scholarship is useful, is it useful enough to warrant a student of engineering to take a bachelor of arts degree before beginning his technical or professional training? Is it wise for him to do so? The answer will again depend largely on the individual student: on what his aims and ambitions are, his means and his age. If he is a student of electrical engineering and his ambition is to become a linesman or dynamo tender; if he is a student of mechanical engineering and expects to do nothing but operate or erect a single class of machines; or if he is a student of civil engineering and desires nothing else than running a level on a locating party; then of course, the answer will be, no. But if in either case the student is to be a master of his profession, a leader of men, if he is to think out plans for others to follow and not be simply a doer of other men's thought, and has the time and money, he should by

all means get a broad liberal education together with a deep technical one.

But since engineering subjects have in them much inherent cultural value, it is not necessary, nor is it wise, to spend four years for a bachelor of arts degree and then four years more for an engineering degree, when in six years all the requirements for both degrees may be fulfilled. The ultra extremists on the cultural side may not admit this and argue that because according to the theory of evolution the "ontogenetic series is a brief recapitulation through heredity, as it were from memory, of the main points" of the entire history of life, the ideal education should include all forms of schooling that have developed throughout the age of man; that this would be following nature and that nature's ways are far superior to man's ways. But the same theory of evolution teaches that when any organ becomes purposeless, it atrophies, becomes rudimentary, and finally disappears. So those subjects, no matter how useful they may have been in the past, if they have now lost their usefulness in part or entirely, should be partially or wholly abandoned. The days of the broad-ax and adz are over for the ordinary carpenter; these tools are relegated to historical museums and are of use only in the limited way that a study of the past may assist us in preparation for the future.

It appears then that only a part of the older forms of education are advisable for the modern engineer. Therefore the course should be lengthened to give those who wish an opportunity to secure such advisable cultural subjects. The more so as all our universities are prepared to give these cultural sub-

jects and can do so without additional expense. The announcement in our college catalogs of such an optional six years' course might lead many to avail themselves of this broader and better training; a training which fits a man to be the social equal of any other man, a training so technical that the possessor can put into practical use the knowledge he has acquired.

The following synopsis of a combined cultural and technical engineering course has been worked out with especial reference to the University of Nebraska. The course is expected to take, for the average student, six years to complete and will embody all that is now required for the degree of A.B., and also all that is required for the degree of B.S. in engineering. Consequently there is no weakening of either course, but on the contrary some electives in our regular engineering courses which may be taken anywhere are by this course required to be taken in engineering lines. The writer therefore believes that upon the completion of this course the degree of C.E., M.E., or E.E. should be given, or at the students' election both A.B. and B.S. in engineering.

The synopsis has been arranged in such a manner that it may be easily compared with existing courses in any college and also with the report of the special committee on requirements for graduation (PROCEEDINGS S. P. E. E., Vol. XII., pp. 99 *et seq.*). The scheme of credit hours is that in use in the University of Nebraska. To reduce it to the scheme of hours work used in the committee report referred to above multiply each credit hour by 3 and the number of actual weeks work in one semester. For Nebraska, $3 \times 17 = 51$ would be the proper multiplier.

SYNOPSIS OF A SUGGESTED COMBINED CULTURAL AND TECHNICAL ENGINEERING COURSE.

I. Requirements for Admission.

For admission the candidate must present entrance "credits" equal to 28 "points." Conditional admission is permitted on a minimum of 22 points.

A "credit point" means the work of five recitations a week of not less than forty minutes each for one-half school year or eighteen weeks.

Required Subjects—22 points

Algebra (through logarithms), 1½ years	3
Rhetoric and literature, 2 years	4
Geometry (plane and solid), 1½ years	3
Language (Latin, 2 years at least), 3 years	6
Natural science (botany, zoology), 1 year	2
Physical science (chemistry, physics), 1 year	2
History (Greek and Roman or American), 1 year	2

In addition to the required subjects, for which no substitutes are accepted, candidates must present six points from the following:

Optional Subjects—6 points

Rhetoric and literature, 1 year	2
History (general or American), 2 years	4
Language (ancient or modern), 3 years	6
Manual training, 1 year	2
Mechanical drawing, ½ year	1
Natural science (botany, zoology), 1 year	2
Physical science (chemistry, physics), 1 year	2
Trigonometry (plane), ½ year	1
Agricultural subjects	10
Entomology, ½ year	1
Astronomy Civics Geology Physical geography Physiology and hygiene Political economy — Not more than 3 accepted	3

II. *Collegiate Course.*

For the bachelor's degree one hundred and twenty-five "credit hours" are required. In the combined

cultural-technical course one hundred and eighty-five hours leads to the degree of C.E., M.E., or E.E.

A "credit hour" is equal to one hour of recitation or lecture a week for one semester requiring two hours' preparation or laboratory work.

	A.B.	C.E.	M.E.	E.E.
Absolute Requirements				
Rhetoric	4	4	4	4
Military drill	4	4	4	4
Pure mathematics		20	20	20
Mechanics		6	6	6
Physics		10	14	14
Chemistry		4	4	8
Drawing		7	12	12
Materials of construction		4		
Framed structures		7		
Machines		2	4	4
Power		6	15	8
Surveying, plane		8		4
Hydraulic engineering		5	2	
Mechanical engineering		3	15	4
Electrical engineering		2	2	18
Chemical engineering				2
Masonry construction		4		
Shop work		6	15	11
Required Electives				
In engineering lines		23	8	6
In non-technical lines:				
(1) Exact science (astronomy, mathematics) .. 10	Any seven of lines (1) to (8) inclusive 50 or 54			
(2) Physical science (chemistry, physics) 6				
(3) The mother tongue 6		Any six of lines (3) to (9) inclusive 40 or 44	40 or 44	40 or 44
(4) The classics 10				
(5) Modern language 10				
(6) History 6				
(7) Biology (botany, zoology) 6				
(8) Philosophy (and economics for A.B. students) 6				
(9) Economics 6				
Electives in above nine lines		20 or 16	20 or 16	20 or 16
Free Electives	67 or 63			
Totals	125	185	185	185

(For discussion, see page 239.)

TECHNICAL EDUCATION WITH A VIEW TO TRAINING FOR LEADERSHIP.

By FRED W. ATKINSON,
President of the Polytechnic Institute of Brooklyn.

The work of modern engineering has resulted in the development of enormous industries which require a degree of skill, intelligence and knowledge, and a high order of executive ability, which was entirely unnecessary in the days of smaller concerns. The demand for trained leaders has thus rapidly increased. Meantime, the whole problem of technical education has changed; technical education while retaining its form has broadened. "To-day, the school of technology," to quote President Pritchett, "is called upon not for a new form of education, but for an adaptation of its curriculum in such measure as to serve the needs of the man and of the engineer." No one questions the value of a thorough technical training, but many do regret that the graduates of colleges of technology are often deficient both in general culture and in those social qualities that make for the highest success. In my judgment, one of the important problems of engineering education to-day is how to give the students a wider culture and how to provide them opportunities for the development of those higher social qualities that make for leadership.

What impresses me most as a comparative newcomer in the special field of technical education, is, first, the fact that there are still many unsolved prob-

lems which only experience can solve, and second, the conservatism of teachers in schools of applied science which makes them unready to try educational experiments. First of all, technical education needs its "Committee of Ten" to do for it what that committee under the inspiring and constructive leadership of President Eliot did for secondary education. We can never form a true estimate of the worth of any kind of instruction, technical or literary, unless we see it in true perspective and proportion, and know the place it should occupy in a scheme of education which regards man in his totality, and not merely on his industrial or practical side.

The special functions of the college of technology as a part of our educational system should be more definitely determined and then an attempt should be made in a systematic way to formulate certain principles applicable to technical education. It is recommended that there be held a conference of teachers of each principal subject which enters into the courses of schools of applied science in the United States, each conference to consider the proper limits of its subject, the best methods of instruction, the most desirable allotment of time for the subject. It is further recommended that a committee be appointed with authority to select the members of these conferences and to arrange their meetings, the results of all the conferences to be reported to this committee for such action as it may deem appropriate, and to form the basis of a report to be presented to this Society. The recommendations of such a committee would at least be authoritative and serve as a definite basis for future

discussions. While there would be considerable diversity of opinion respecting many of the recommendations,—due largely to different local conditions,—yet I believe there would be substantial agreement upon many more. Without much doubt the committee would be able to construct sample programs, one, for example, showing the minimum amount of technical knowledge which should be required of the young engineer for graduation, one the course of study to be pursued by the college graduate as he enters upon the school of applied science as a professional school, and another embodying the growing tendency to give in the technical school rather than in the college the general education which constitutes culture. Four, five and six year programs should be included in the work of the committee. The differentiation in the programs will represent approximately the classification of the existing technological institutions.

The engineering schools may well consider their duty done if they provide the constantly increasing technical knowledge required and turn out good engineers. An engineer if he has it in him to become a great man, may ascend through his profession to any height to which his talents are equal. But large success is becoming more difficult. The industrial world is becoming more complex, more complicated, more confusing. Opportunities are greater than ever before only to the man who can add to a more intensive technical knowledge, a wider grasp of industrial affairs and an ability to deal effectively with men. Is it possible then to devise any practicable plan by

which certain technical schools can raise their ideals and furnish an environment where men may develop broadly with a view to increasing their educational and professional efficiency and thus fit them for positions of executive responsibility? I believe that there are certain institutions financially able and so placed as to do this, and thus advance the standards of admission to the ranks of engineers and exalt the profession's dignity. The limitations upon such an undertaking are clearly recognized. High proficiency in engineering can never be reached without natural ability and long experience. The engineer forms no exception to the law that experience is an imperative necessity for every human being. A school can no more turn out completely developed and efficient engineers ready for leadership than it can produce lawyers and doctors expert at the day of their graduation.

The ideal plan which I shall outline in detail, is not offered as taking the place of ability or practical experience, but as supplementing them under particularly favorable conditions, as furnishing an environment where men can develop broadly for all the work of life, and become efficient for engineering positions of executive responsibility.

I believe that any one of the large private technological schools could with success train specially for leadership by inaugurating selective process, say, at the beginning of the third year and enrolling the favored ones for a course leading to a different degree and requiring an additional year. I should prefer, however, that the selection of the raw material came at the beginning of the second year provided the in-

struction in the first year was individual in character and that it were possible to determine with considerable degree of accuracy just which students had shown the native ability for the higher course. The selective process should, however, begin earlier—with admission.

Impressed by the rapidly increasing demand for trained leaders in every department of engineering, the Trustees of the Polytechnic Institute of Brooklyn propose (provided there are sufficient funds available), to erect upon the traditions of that institution a school of engineering that shall make primarily for the highest efficiency. About one million dollars has been pledged by them, a sufficient indication that they believe in the work.

It will be a small school. With the number of its students limited at the most to three hundred, it will ensure to each the fullest personal development. Each will be dealt with as a separate problem. From the day of entrance he will in lecture room and laboratory come into immediate touch with professors of experience and eminent specialists.

It will not only be a small school but a school of picked men, assured of attaining high excellence. The merely average student will not be desired or admitted. It will attempt to address its teaching to the ablest. Instead of diffusing its energies in producing ten men for the ranks, it will concentrate every resource upon developing one thoroughly equipped officer. It will bend every effort to develop professional leaders. To accomplish such a purpose great care will be taken in selecting the choicest material. Weight will be attached to the candidate's personality.

Recommendations of his fitness will be investigated. This will not be difficult, for the large majority of the students will receive their preparation in the immediate neighborhood. The conditions for entrance will be unusually high, but they will also remain remarkably flexible. As the passing of certain examinations will not alone qualify for admission without evidence of the traits that make for leadership, so lack of preparation in one or several respects need not of itself disbar from entrance. Talent rather than conformity to absolute standards will be the passport. On the other hand, mere brilliance will not alone constitute the test of fitness for entrance. Genius, defined as talent for the taking of infinite pains, includes in its range many minds that move slowly, yet with power and precision. Since not only the conditions for admission but the rate of advancement will be largely an individual matter, men of marked native strength of resources, persistence, and capacity for growth will be received and encouraged, even though their course may outlast a year or two of the brilliant vanguard.

With its premium placed upon quality rather than size, this school will sift most thoroughly even such students as it finally accepts. Only a definite number will be admitted and one half of these may be cut off before the end of the first two years, and but one third graduated. The plan of admission and elimination of students is not unlike that of our Naval, and Military Academies. A similar procedure is followed by some of the French *lycées*. It is very doubtful if this could be done in any but an institution supported by private funds.

Careful attention will be given to the physical condition of students. Work in the gymnasium will be required throughout the course and there will be frequent physical examinations. The so-called outside college interests—the dramatic, literary, musical and debating societies, and the dances—will be fostered. The fraternities will be encouraged to build their chapter houses on or near the grounds to be provided for the college. Every endeavor will be made to increase the social opportunities of the students, to bring them in contact with the people of the community in a social way, to have them hear and meet men of large affairs. The membership of the professional societies will be made up, as they are now, of undergraduates, graduates and instructors and professors.

Quite as essential to the successful operation of this plan as the gifted student will be the gifted and inspiring teacher. The endowment proposed by the Trustees of the Polytechnic Institute of Brooklyn will be adequate to secure for its faculty men of broad culture, high scholarship, and ripe teaching experience. By the limiting of the classes and the ample provision of such professors in each department, all, or nearly all, instructors may be dispensed with. Every student will enjoy direct association with the heads of the departments, a privilege usually accorded to the few. Moreover, the regular staff will be supplemented by expert engineers of national repute. These consulting professors from their wide experience and study of actual conditions will keep every course in alignment with the advancing margin of engineering practice.

In its courses of study, the school will provide for the professional training of civil, electrical, and mechanical engineers, and for the prosecution of scientific research and experiment in these departments. It will offer admirable facilities for the education of those upon whom will devolve the conduct of great commercial and industrial enterprises. While each course in its minimum requirements will be so exacting that only the gifted, ambitious, and persistent can hope to succeed, yet beyond such limits each will be elastic, admitting and encouraging breadth and freedom of personal development. The laboratory method will be greatly emphasized. Personal conference will supplement, if not replace, the impersonal lecture. Experienced and tactful teachers will strive to call out what is best in each student, rather than merely to offer him what is best in themselves. Such a method will do much to guarantee that thoroughness and capacity for independent thought and action so requisite to the leader. But these courses will be broad in culture as well as intensive. The sin of the technical school is narrowness. Here the fundamental sciences—mathematics, physics, chemistry—will be presented not merely with reference to their applications, but with regard for their intrinsic significance as essential elements of a general education. The modern languages will be studied, not alone as a means to acquaintance with the scientific work of other countries, but also as a linguistic and literary training. Especial stress will be laid upon acquiring the mastery of English as an instrument of thought. Through constant practice

in writing and individual criticism in conference, each student will be assured command of a clear, exact and vigorous style. The study of literature will not only further this end, but will afford acquaintance with the best that has been thought and finely expressed in the language. Indeed, English and American literature, American history, and the history of modern Europe will be taught primarily for the grasp they must yield upon social, moral, and political questions, while the study of economics will possess peculiar significance for those ambitious to deal intelligently with great industrial problems and processes. It is proposed that all such courses, so far as they extend, shall be more thorough, more exacting and comprehensive than those presented by the colleges. The need for this is apparent. The technical student will systematically survey these fields but once; the pace will be too rapid to allow of his easy reliance upon some future opportunity to approach them; moreover, within a given time he must travel over a greater sweep of their territory. With the standards of such subjects ranking no lower than those of his purely professional courses, the student will not only cease to regard them as intrusions, but will recognize in their broadening influence his most profitable investment of time and effort.

The length of the undergraduatae course will be indeterminate. The best among the best may finish within four years; for many, perhaps most, an additional year will be necessary.

The unparalleled range of engineering practice afforded by Greater New York will serve, not merely

as an inspiration to the engineering student, but as an essential part of his subject-matter. He will investigate theoretical problems in the light of the best actual practice, inspect the largest and most varied engineering works and operations, and at every turn supplement book-knowledge by the knowledge of existing conditions and requirements.

It is evident that such an institution for the education of leaders must be private in character rather than public. For the public institution, deriving its support from all, must in turn cater to all. It must diffuse its energies to shape its many, rather than concentrate them in more highly developing the few.

I am distinctly conscious of the limitations and responsibilities such a plan imposes on those who undertake it. I would rather, however, place emphasis on its possibilities. You will bring up doubts, point out serious obstacles, say perhaps that it is a "piece of idealism," but I can only ask with a dash of perversity, "isn't it an educational experiment worth trying?" May it not, if wisely administered, show that efficiency in education and efficiency in training can go together?

Joint Discussion.

Professor Rowland: The proposition of President Atkinson's paper is a most interesting one. It seems to me to be especially interesting since it is so different from much we hear nowadays, or have heard even in some of the papers presented at this meeting, the latter's aim being somehow to combine trade-schools or industrial education with engineering courses.

I am glad that an experiment of the kind proposed in this paper is not going to be tried upon my son or upon any man to whom I might hold the relation of teacher. I know of nothing in teaching work which is more pitiful to contemplate than the wrecked courses of men who for various causes have been dropped by the wayside and left behind by their classmates on their way toward graduation. Too often, and in too many courses, students are dropped out because a policy of exclusion is adopted by the faculty, whose motive is to weed out all but the most brilliant men. This seems to be the aim deliberately chosen by President Atkinson for his proposed course. I cannot feel, for one, that this is a proper aim in educational work.

I believe a faculty should put itself into such an attitude that it is constantly looking about to see how better to adopt the courses to the students in them, to arrange so that as much as possible can be done for each man, and to plan so that a helping hand may be reached out as far as possible toward each one. I believe in planning courses with this end in view. Few men really start on an engineering education who have not, for some good cause, selected it as the means of finding the station in life for which they are fitted. The training they expect to get is only taken with a view to gaining ability to fill higher places than otherwise could have been reached by them. Turn such men away, or drop them out when part way through a course, and by that very action they will have been given a blow which will be felt through their whole life.

Give men a properly rounded course in engineering principles, built up on the science and mathematics which form a necessary foundation for such education, and their own natural ability will attend to the future. This it is sure to do anyhow. Only those men who have qualities for leadership will ever get into positions where leadership is required. Alas, in many cases the very men who would have been picked by a faculty to become leaders in professional work are distanced by those who have been scarcely able to pass graduation requirements.

The Secretary: In this connection, the following excerpts from the reply of Professor John Perry, of the Royal College of Science, London, to my invitation to become a member of our Society may be of interest. He writes, "May I suggest, however, that you Americans are trying to do too much at College. You are trying to teach *everything* at an Engineering College. It seems to me that a college ought to teach a man how to go on *educating himself* all the rest of his life after he leaves college; it ought to make him fond of reading. If this is the aim of a college then a six or a five or a four years' course is all too long. A three years' course is quite enough if your entering students know how to write a letter in English, and how to compute, and if they have some knowledge of experimental science. All the rest is Bunkum and Tom Sawyerism.

"P. S. I mean that Latin, Greek, French and Germen are all good, but they are not necessaries of life."

Dean Kent: It was brought to my mind in this paper that the recent literature on biology shows that the doctrine of the survival of the fittest is getting out of date, and that the doctrine of mutation and sport is coming to take its place; namely, that progress does not come through very slow changes through the centuries, but through sports, the sudden action of some one thing that goes away from the established order of things and brings in a new one. In engineering education one of the sports is the individual instruction of Dean Raymond; another is Dean Cooley's six years' course; and here we have President Atkinson's new experiment. I am in favor of all of these experiments. The present styles of schools of engineering are all right for the work we have to do, the training of the average engineer. A far larger problem is the problem of industrial education, and a still different but much smaller problem is the training of a small number of men for the highest efficiency.

Dean Goetze: I desire to endorse what Professor Chatburn has said about the importance of the combined academic and technical course and wish to say that at Columbia University we have been fostering this course to the greatest possible extent for several years. We are strongly advising entering students to come up to our engineering courses by way of the college and there are now some thirty or forty of our students who are taking this combined course. They come into the technical school better prepared and more mature and are consequently better able to keep up with the hard work which is required of

them in our engineering courses. It is interesting to note that of the three men who were selected by our engineering faculty as the most faithful and deserving students in the recent graduating class two had taken the six-year combined course.

PRESIDENT HOWE: We have a combined cultural and technical course lasting five years, different from those that have been described. As we are a technical school we cannot give the cultural subjects ourselves but we are on the same campus with Adelbert College, although entirely distinct from that institution. We have made an arrangement with them whereby a student may enter Adelbert, remain there three years, and then come to us. If in those three years he takes the subjects which we give in the first two years—mathematics, English, modern languages, physics and chemistry, he can complete our course in two years. This means that Adelbert takes the man for three years in regular college work, and the fourth year is elective. Adelbert allows this student to elect technical subjects. In the fourth year he is at Case but completes all his work at Adelbert and gets his degree. Whatever of our work he does not do in Adelbert, he does with us. He does not miss any technical work, and in five years he completes both these courses without any difficulty. So ours is a five-year combined course of cultural and technical subjects. This arrangement has been in force for four years. But as the men have to stay in Adelbert three years before coming to us, we have as yet received only one class. We had nine men last year, and fifteen are coming next year. I understand that

quite a large percentage of the students at Adelbert have elected this combined course. I believe in it, because it gives us a class of men who know what they want; who, when they come into the technical school, are prepared to go on with the work and are perhaps broader, more earnest than the fellows who have not had this additional training. I believe they will be better citizens, enjoy life more and have a broader outlook. I do not know whether they will be any better engineers.

Professor F. C. Caldwell: What President Howe has said leads to another branch of the subject, namely the combining the work of the colleges and technical schools with that of the non-technical schools in their vicinity. I see no reason why the work of the first two years in almost any technical course should not be included in the four years of almost any first-class non-technical college. So that the graduates of these non-technical colleges after they have taken their degree can go to the technical school and in two years more complete the work for a technical degree. All that this requires is, that during the four years of their non-technical course they should include the subjects of the first two years in the technical school.

Dean Woodward: It seems to me it goes without saying that, with equally good teachers and facilities, you can do more with the bright fellow in six years than you can in four. You can make a more cultivated man and a more accomplished man. It is all right if you can get the students to do it. If circumstances are such that they can take advantage of

the six years' course, we would be glad if they would do it. As I understand it, the doors are always open for them to do that. I do not know of any institution which has on its campus facilities for the ordinary literary college and engineering college also, where that is not possible. But what are we going to do? We have a vast body of people who cannot spend six years. They are not inferior in ability for scholarship nor in potential executive ability. There is no antagonism between the two. It seems to me everybody likes more if he can get it.

Professor Haupt: Following the lines of President Howe and Dr. Woodward, I think we can learn a great deal from experience, and I am going to speak briefly of the experience I had in a University. In 1872 descriptive geometry was not taught in the scientific department. The idea of educating a civil and mechanical engineer without a knowledge of projection drawing was so impracticable that I volunteered to instruct the sophomores if the faculty would add it to the curriculum, which was done. Some time afterward an effort was made to abandon it again but without success. The question that Dr. Kent has raised is important as to this matter of drawing, which is the fundamental language of construction.

I would like to supplement the general feature of a longer course by saying that it would be a very great advantage to our technical school graduates to understand modern languages, particularly Spanish, for there is a great demand for American engineers in Central and South America. With reference to the five-year course we have had some experience.

Under the four-year curriculum two years were devoted to general culture studies, and the last two were technical. When it was increased to five I found it necessary to give almost my entire attention to the post-graduate work, which consisted in visiting the shops and structures, having the students prepare reports and illustrations, of plants for criticism. That took up so much of the time, that the professor in charge of the department had very little to spare for the under-graduates, and was obliged to turn them over to his assistants, which was detrimental. I believe the head of the department should be in personal contact with all the members of the student body. Students should be taken into the field or shop quite frequently but it is also important to have experts in engineering from all parts of the country, to deliver lectures, on special topics, and show them the breadth and scope of the engineering professions, still undeveloped.

Professor Franklin: I feel very strongly regarding what I consider to be a widespread presumption on the part of teachers to be able to size up men without question and without appeal; and, although I should like to see the experiment which the author mentions tried by the Brooklyn Polytechnic, I believe that the only way to train leaders is to train them with followers, and if I were an employer of graduate engineers I would much prefer to take the one man from a school for all kinds of students—good and bad—who was the best man of the class, than to take a man coming from a school which claimed that all its men were leaders. The much used ex-

pression "training for leadership" is no doubt very fine, but to my mind it is also false and foolish, as well as fine. Let us stick to the homely idea of "training for service."

PROFESSOR CONSTANT: I am very glad to hear from Dr. Howe that the five-year course is practical and successful in Case School. We have had a five-year course at the University of Minnesota for some years, and we have found insuperable difficulties in arranging the schedule of hours. The five-year men take the bulk of the technical subjects belonging to the four-year course, plus a certain number of culture subjects in the college of science, literature and arts. In trying to fit the hours of the two colleges the student gets into difficulty. He may be able to get through the freshman and sophomore years all right, where there are many sections for each subject, but in the higher technical classes where there are only one or two sections, it is very troublesome. It has resulted generally in his taking six years to accomplish what we had hoped he would do in five. But no one can question the wisdom of a five-year course, if it is practical, which contains a certain amount of the general culture subjects. The general four-year student after entering college gets little enough of that, practically none at all. But I think the question might be raised whether six, or a greater number, of years of engineering education is better than five years or less. We must remember that education fits primarily for service in life. We must also remember that the essential training of an engineer is somewhat different from that of a physician,

for instance, whose last years of preparation are spent in hospitals and in attending clinics, where he is in the same atmosphere, meets the same men and finds the work almost identical with that of his future professional life. With the engineer, however, there is a very broad element of training which he cannot get in college, because the engineer's work is with men—with common and uncommon men, working men, men in all walks of life. He cannot be a leader, his character cannot be developed (for character is not synonymous with education by any means), until he has had the experience of personal contact with these men; and it seems to me that it is possible for him to delay this contact with the outer world and the men he is to deal with later until after the formative period of his life has passed. Possibly some of this experience may be obtained by a conscientious effort on his part to get into the shops and field-crews during the vacations of his college years; but unless he does that, he is apt to come out into the world at twenty-four or twenty-five or more, too old to adapt himself to the conditions of what we may call the lower spheres of life. It is absolutely essential that he should have a working knowledge of men, and that working knowledge can only be obtained by working shoulder to shoulder with them, during the years when he is not ashamed so to do, and when it is very natural for him to mingle with all classes. So, as I said before, it is possible for one to get too much of a scholastic education at the expense of the real vital experience with the outer world. I understand that the University of Cincin-

nati has inaugurated a system of coöperation with the shops of the city whereby students may obtain practical shop experience and academic training simultaneously. This is a practical recognition of the principle I have just stated and I for one shall await the outcome of the Cincinnati experiment with great interest.

DEAN RAYMOND: Professor Chatburn has wondered whether he will have any students in the six-year course. He will. In Iowa we are more nearly situated as they are in Nebraska. Last year forty per cent. of our freshman class were more or less self-supporting. It is entirely possible for graduates of our College of Arts to finish the engineering work in two more years if they have made proper elections in their college course. We graduate one such man this year, another next year, and probably one or two the year following.

Defending Professor Atkinson's theory of training leaders from the attack made by Professor Franklin, I fancy if Professor Franklin had been trained thirty years ago in language and poetry he would be a leader to-day in literature and politics. Professor Atkinson proposes to pick the best men he can get for the purpose indicated, and then to train them in the best and most efficient way—individually.

PROFESSOR D. C. JACKSON [Secretary in the chair]: This paper of President Atkinson contains a number of pertinent suggestions. I commend a number of the paragraphs to the thoughtful consideration of this Society. Now, I wish to add, that I do not agree

with Professor Franklin's views and arguments. The engineering teacher ought to study his students with great care and become acquainted with them and with their characters in a manner that is analogous to the manner in which an executive in an important industrial enterprise studies his subordinates. Such a man is able to weed out the poorer men and drop them into some other enterprise, while he selects the better men and boosts them. It is the duty of the engineering instructor, if he is doing his best by his students, to study his students in the same way, and to do it even more carefully if possible. If he gets acquainted with the characteristics of his students in such a complete manner as they pass through his classes, he will be able to say with a reasonable degree of certainty which of the men are going to be the leaders twenty years hence, and which are going to be the men that will never be able to advance beyond the positions of foreman or superintendent, or something of that nature.

Professor Cooley: I wanted to refer to Professor Kent's remarks concerning the four-year course, and the requirements of Latin for entrance. He carried me back twenty-six years. When I went to Michigan I had the same view regarding what a course in engineering should be. Then we aimed to make a young man able to do some one or two things. We attempted to accomplish that much, anyhow. But I have a different opinion now, due, I suppose, to the fact that I have been teaching engineering for twenty-six years.

While it is well that a man shall be able to do

some one or two things at least on graduation, it is far more important to-day that he shall be broadly educated, that his education shall fit him to mingle with men and be a leader among them socially as well as professionally. The opportunities for good influence are great, and he should be trained so as to make the most of them.

The young man's preparation for college should be of a kind which will admit of rapid progress after he enters. First of all, in preparing for college, he should have learned how to study. The neglect of this is a sad defect in our preparatory schools, and must I believe be conceded to be the cause of most of the failures which befall the student in his work, and which lead to great and sad disappointments on the part of student and parents alike. Personally I do not care so much what his preparation covers if he has really learned to study. He must of course be entered on the subjects which are to be continued immediately after he gets into college. These are the required entrance studies. The others are immaterial; or, at least, they are not so very essential. At Michigan we like to have a young man come with two or even four years of Latin. We will credit him with Latin on his English entrance requirements if they are deficient. We are glad to do that. We also give a man credit for Greek. We recognize two years of Greek and three years of history, and personally I would recognize anything else that makes for the training of the student preparatory to taking up college work.

I would like to make this point in relation to the

four-year course *vs.* the five- or six-year course in engineering. Twenty-five years ago in Michigan there was no field for mechanical engineers. I had lived in Michigan three years before I struck my first professional job, and when I rendered my bill at ten dollars a day, it caused surprise. They said they never heard of such prices. Referring to our course of instruction they said, "Your men can't do anything. We want practical men." That was the talk twenty-five and twenty years ago, and even fifteen years ago. But now, what do these men say when they write for graduates. We do not have to offer them our graduates now. They say, "Give us technically educated men. We don't care whether they are civil, mechanical, or electrical engineers. But we do want them technically educated." If that is the demand to-day, it is not so necessary for us to start the student engineer so as to get certain subjects into his four years. I say, give this young man a general training in the engineering subjects which are common to all branches of engineering, and at the end of four years graduate him. Offer courses for the fifth year, and for the sixth year if you will, in advance of those that are offered for the four-year course. Let a man specialize along any line he pleases in his fifth year, and at the end of that time give him a master's degree. We have a number of men every year who are working for the master's degrees in engineering. We have graduates from the literary department coming into the engineering department taking five and six years to complete their studies—A.B. men—and they graduate with us as

B.S. men. We believe it to be in accordance with the demands of the day to give engineering students a broad general education regardless of the particular profession or calling that they will eventually follow; let them specialize after they graduate, according to the demand. I insist that we make first, men fitted to become engineers,—not civil, mechanical, or electrical engineers,— in the four year period of time and in that time provide them with a foundation suitable to build upon in any branch of engineering. That I believe to be the real demand of the day. Now in regard to Professor Atkinson's paper—leaders are born; they are not made.

PROFESSOR WILLISTON: It makes very little difference what speciality a man takes up in college. If he has taken the work in the right way and has gotten the spirit of it, he will be able to meet, with little difficulty, the problems that are likely to confront him later. The demand unquestionably is, as Professor Cooley has said, for men who are broadly trained with a thorough understanding of the foundation principles of engineering. Nevertheless, I think there is a serious error in the ideas which he has just expressed; and I believe that we would make a mistake if we were to attempt to carry out his suggestions in practice. A broad and general training is good, but before we may be sure that this is the best that is possible the individual student, as he enters college, must first be considered. He often has very definite notions of what he thinks he is going to do after his graduation and his ambitions should be kept in mind. We wish to teach him the

general principles of engineering but we can do this just as well by teaching surveying in the field, or foundry practice in the shop, or chemistry in the laboratory. It is absolutely immaterial what medium we use through which to give him this general engineering education. If we as teachers have the spirit of the engineer, we can give it to him through any one of these channels. But if, on the other hand he has made up his mind to engage, as his life's work, in a given field that will determine the way to best teach him those things that every engineer wants to know, for he will put his heart and interest most cordially into what he believes will help the most toward his success.

The extent to which we should specialize, however, is largely a question of efficiency. If a large number of young men enter a university and some of them think they want to be electricians, others chemists and others naval architects, and still others highway engineers, we may as well put them in different sections under different teachers in courses called by different names, and teach them all very nearly the same things, using only different subjects through which to convey the same ideas. If there are enough who elect each of these specialties to properly fill the classes and to occupy the full time and attention of the corps of teachers and to efficiently use the necessary laboratories and equipment there is nothing lost by this specialization and the gain may be great. If on the other hand, the specialization means the separation into two or more classes of small groups of men who could otherwise be efficiently

taught in a single section there is likely to result an increase in expenditure, or loss of efficiency in other directions, which will make it unwise if not unwarrantable.

In first year mathematics at Pratt Institute, we have a large number of men who are entering either mechanical or electrical or applied chemical courses. We wish to teach them all very nearly the same things. They must all learn how to solve equations and all must acquire accuracy in obtaining their results. We could teach all in different sections of the same class, but practically we find there is great advantage in having those who are to take the electrical course taught by a man who has had an electrical training who can make his illustrations and problems and often the notations that he uses such as have some direct bearing on electrical work. For the same reason the man who teaches those who enter the chemical course is familiar with chemistry and is able to adapt his instruction to their particular needs and to correlate it with the other subjects in their course. In all subjects we do not have a large enough number of teachers to make it possible for us to carry out this idea, but we do it wherever we can; and in each case where it can be done there is a distinct gain.

Professor Chatburn: Dean Kent asked why drawing was not made a required subject for admission. The answer is that the secondary schools of Nebraska are not yet prepared to teach the subject. If a student offers drawing, credit is allowed. Some one thought a student after taking a six-year course

would be too old to adapt himself to the requirements of a practical engineering life. Such has not proved to be the case in medicine and law. Dean Cooley asks for "a technically educated man" well-trained in "general engineering." The six-years course ought to give him what he wants, and, in addition, a cultured man.

Lord Kelvin says the first object of an education is "to enable a man to live," and the second, "to assist other men to live." The first object may be attained by the tradeschool or the purely technical engineering education, but the broader the culture a man has the more will he be enabled to fulfill the second object.

THE FUNCTION OF THE DEAN OF A COLLEGE OF ENGINEERING.

BY F. E. TURNEAURE,
Dean of the College of Engineering, University of Wisconsin.

The great increase in attendance in schools of engineering during the past few years has made the problem of administration a very important one and one which has in many cases required changes in organization and in the functions performed by the various administration officers. In the separate school of technology, the duties of the dean are likely to be quite different from those which he is required to perform in the large university where the engineering department constitutes one of several more or less independent subdivisions. As the latter case is the one covered by the writer's experience, it will be the one which will be here considered.

In the modern large university, the various departments are usually grouped into schools, or colleges, corresponding more or less closely to the various groups of academic or professional work taught in the university. Up to the present time, no one particular method of organization has been generally adopted so that there can scarcely be said to be an organization which is typical or standard. Existing organizations are the result, largely, of tradition and evolution, and the conditions are so greatly different in different institutions that an organization suited to one place will hardly be suited in all respects to an-

other. The tendency seems to be towards the formation in the large universities of a school, or college, of liberal arts and of various professional or semi-professional schools, or colleges, of law, engineering, agriculture, medicine and the like. The relation of these several departments to each other depends to a considerable extent upon the respective rank of the various schools in the matter of requirements for admission and graduation. In some universities, the professional schools are virtually graduate schools, being thus equal in rank with the post-graduate work of the college of liberal arts. In most universities, however, the various departments are of fairly equal rank and especially as regards the departments of engineering and of liberal arts.

In the University of Wisconsin, the organization is a simple one and, so far as it concerns the engineering departments is similar to that already existing in several universities and which seems likely to become quite general. The university is composed of four colleges; the college of letters and science, the college of law, the college of engineering and the college of agriculture. Each college has its separate faculty, presided over by the dean and composed of all those giving instruction of any considerable amount to the students of that particular college. The faculty of the college of engineering thus includes certain professors of mathematics, physics, chemistry and the like, although those professors who give instruction to occasional students only are not considered members of the engineering faculty.

The university faculty is composed of all members of the instructional staff.

All college matters pertaining to the students of any college are controlled by the faculty of that college. This includes such matters as scholarship, recommendation of baccalaureate degrees, minor cases of discipline, etc., and the initiative regarding courses of study. These last are passed upon by the college faculty and go to the university faculty for final action. An important duty of the dean is to act as presiding officer of the college faculty and member of all its committees. Business transmitted to the university faculty is presented by him.

The dean is also the executive officer of the college in the departmental and business relations, and in these matters is directly responsible to the president. The ordinary routine of business of all departments in the college is therefore through the dean, although any officer may bring directly to the attention of the president anything which he thinks of such importance as to render this desirable.

To make clearer the relation of the dean to the departments of the college of engineering in the University of Wisconsin, it should be said that in the organization of the technical departments, each department is under a head professor, who is directly responsible to the dean. The number of departments is much larger than the number of courses of study and does not correspond in general with such courses. Thus, there is a department of railway engineering, a department of hydraulic engineering, a department of steam engineering, etc. There is no department of civil engineering, nor of mechanical engineering. The departments are thus organized with reference

to the nature of the work to be taught, and not with reference to the group of studies making up a prescribed course. They are thus organized exactly on the same basis as the departments in a college of liberal arts. There are provided the usual courses of study—civil engineering, mechanical engineering, etc. These are arranged with reference to the needs of the students and not at all with reference to the departments of the instruction. The department of hydraulic engineering gives all the instruction that is given in hydraulics; the department of mechanics, all the instruction in mechanics, etc. Such matters as pertain to the administration of the group of students taking the civil engineering course, for example, are referred to a committee on the civil engineering course, consisting of four or five professors whose time is devoted mainly to the civil engineering students. Under our system of student-advisers described later, matters of this sort are not numerous.

The number of relatively independent departments and of professors of full rank is thus larger than is likely to be the case where the departments correspond to the courses of study. There are eleven independent departments in the college. For faculty purposes the college of engineering, as already noted, includes teachers of certain non-technical studies; for purposes of departmental and business administration, the college includes only the technical departments.

The annual budget, relative to the teaching staff and to all expenses of the college, is prepared by the dean from recommendations by the heads of depart-

ments and upon consultation with the president. He is expected to take the initiative in recommendations regarding head professors, but recommendations regarding subordinate members of departments are expected to come to the dean from the heads of the departments. These recommendations are transmitted to the president and by him to the regents. All formal communications thus pass to the president through the dean; but it is, in many cases, helpful for various members of the college to consult the president directly regarding matters in the department.

The budget for apparatus and improvements for the college of engineering is usually passed upon by the regents in one lump sum to be expended through requisitions approved by the dean and president, and authorized by the executive committee of regents up to the limit provided for in the budget. All purchases are made on orders based upon approved requisitions, which orders receive the approval of the dean and are then transmitted to the business office. All bills of whatever kind are sent from the business office to the dean's office, and thence distributed to the several departments for inspection and approval, after which they are returned through the dean's office and receive his approval, and then go to the business office for payment. The distribution of the apparatus fund is made by the dean in consultation with the heads of departments. This is a matter of much importance, as the available amount of money is always insufficient for the needs of the college.

The dean is thus made responsible for all expenditures and his office is, to a considerable degree, a

business office for the approval of purchases and the auditing of bills.

In the large university, one of the most important and perhaps most difficult matters of administration is that of the supervision of the work of the students of the first and second years. The small college is now-a-days making the most of the proposition that the welfare of students is looked after to better advantage in the small college than in the large university. In some respects, there is probably some truth in this statement, especially with regard to the immature young man whose habits of work are not very strong and whose moral fiber is not sound. We all recognize the type of student; but I think we will agree that the average student in an engineering school will belong to the type of industrious student who is in no great danger of falling into bad habits through too large a measure of liberty. This question will always be an open one, but as the engineering school approaches more towards the professional basis, this problem will be of less importance.

In the University of Wisconsin, the supervision of the work of the younger students is a subject which has been very carefully considered, especially within the past three or four years, both with respect to the character of the instruction given and to the system by which their progress may be noted and deficiencies checked. In the old-time small college and in many universities, one of the chief functions of the dean relates to this part of the work. In a department having 700 to 1000 students it is, however, obviously impossible for the dean personally to super-

vise this work. In the arrangement of studies of students, especially where many are irregular and in arrears, in the checking up of deficiencies, interviewing of students relative to such deficiencies and the checking up of semester records with reference to action on deficient students, there is involved an amount of work which would if undertaken by the dean, absolutely prevent him from attending to anything else. It is perhaps in respect to this function that the methods employed in the University of Wisconsin differ from those in most other places.

For many years there has been in operation what we call the adviser system. As many inquiries have come to us regarding this system, it may be well to explain it in some detail. In the college of engineering, the supervision of students is in charge of twenty advisers. The freshmen, who are not classified according to courses, are divided among four advisers, alphabetically. The students of the sophomore and upper classes are divided among advisers according to the course of study pursued. All these advisers are professors in the technical departments. They are selected with reference to their familiarity with the major work of the students, and so far as possible, the adviser also comes in direct personal contact with the student in some of his classes. Thus, among the freshmen advisers, is the professor of the freshman drawing who meets all freshmen. In the sophomore and upper classes, the adviser for civil engineers is some professor in topographic, railway, or hydraulic engineering, and so on. After the formal registration, and payment of fees the student confers immedi-

ately with his adviser with reference to his proposed program for the coming semester. If his work is regular, the adviser approves the program promptly, and cards are at once made out by an assistant which will admit the student to each class. The adviser retains a copy on a printed blank of the student's studies so selected. If the work is irregular, the student must select his studies in accordance with the requirements of the catalogue and of the time schedule, and this must be approved by the adviser. Upon such approval, cards are issued as above mentioned. Where the work of the student is in arrears in any respect, this matter is checked up by reference to a copy of the student's past record which is furnished the adviser from the central office. As a guide to the adviser, the faculty has adopted a few simple rules regarding extra work and elective studies which are of such a nature that the adviser is able to settle almost all cases without reference to the faculty. It should be said also that any faculty action regarding a student's conduct or studies is entered upon the transcript of record already referred to, so that the adviser has the whole history of the student before him.

The class cards issued to the student constitute his authority for admission to classes. They are presented to the various instructors at the first meeting of the classes in accordance with posted time schedules. At the end of the semester, the record of the student's work for the semester is entered upon these cards, the cards signed by the instructor and then sent immediately to the adviser whose name appears

thereon. Within a day or two after the final examinations the several advisers meet in executive committees, the advisers for each class constituting a separate committee. The work of deficient students is then discussed and suitable action taken as to the dropping of students, or giving warnings, etc. The work of the dean in this connection is of importance as it is his duty to attend these adviser meetings where he is able to make suggestions which will insure that actions may be reasonably uniform and consistent. In the case of freshmen, reports from instructors are received two or three times each semester. The information thus supplied is made use of in interviews with students and in recommendations at the end of the semester. Reports of poor students of other classes are received, ordinarily, only once during the semester. By these means the history of each student is before the committee and he is, furthermore, personally known to one or more members of the committee. It is the policy of the university to encourage, in every way possible, the young men just entering upon their work, and to check up deficiencies as soon as may be. Students in the later years of the course are not given the same attention. They must stand or fall upon their records.

The university has no fixed rules concerning the number of conditions or failures which will bar a student from the university, or the amount of work which must be passed in order to remain. An effort is made to consider all the circumstances of each case and to pass judgment accordingly. Positive action is thus necessary to bar a student from the university.

Having taken this action, students who are dropped are not often readmitted, except in those cases where, through additional preparation, or practical work extending over a period of six months or a year, it seems reasonable to suppose that the student is in a position to do better work.

Our experience with this system is, on the whole, very satisfactory. We are quite often visited by parents of students who desire to look into the cause of their son's deficiencies. By conferring with the adviser they are given all the facts in the case by one personally in touch with the student.

The administrative work by being thus distributed among a large number of persons is not burdensome to anyone, and probably does not give more than the desired amount of experience with such matters for the best interest of the advisers themselves. The dean is, of course, relieved, and, in a sense, the faculty also, so that this administrative function may be said to be not an important function of the dean in our institution except in an indirect way.

Besides the definite functions already mentioned there are many other less definite functions, as all will recognize, that go with the office of dean. One of them is what may be called the "patriarchal" function—that of being general father and adviser to students. To what extent this function is exercised depends largely upon individual temperament and inclination. With the adviser system this work is naturally limited to the more important matters. It is our custom to meet the freshmen in one or more general talks at the opening of the year in which some useful hints may be given.

As a member of the university faculty and of its committees, the dean is in the same position as any of the more experienced members and the same is true with respect to his relations as general adviser to the president. But, at the University of Wisconsin, there is no recognized small body of professors, as a senate or cabinet, such as exists in some institutions. The only units recognized are the department, the college and the university.

THE DUTIES AND WORK OF THE DEAN IN A COLLEGE OF ENGINEERING.

BY JAMES M. WHITE,
Dean of the College of Engineering, University of Illinois.

As the influence of a dean should extend beyond the sphere of his own college, it is necessary to consider his position in its relation to both the general university and college organizations. This relationship at the University of Illinois is shown graphically herewith, the lower half of the diagram representing the college of engineering and the upper half the general university organization.

The students have direct dealings with the officers of other colleges in which they elect courses, with the registrar who admits them to the university and keeps the official records of their work, with the chief clerk to whom they pay their fees, and with the dean of undergraduates who is their special adviser.

The members of the faculty with the rank of full professor and others who are acting heads of departments sit in the senate which exercises legislative functions touching the educational policy of the university. The council is the executive body and includes the president, vice-president and deans. It does not exercise general legislative functions, but acts in an advisory capacity to the president, touching the discharge of administrative duties, and has exclusive jurisdiction over all matters of discipline.

The college faculty exercises legislative functions touching any matter appertaining exclusively to the internal work of that college and the progress of stu-

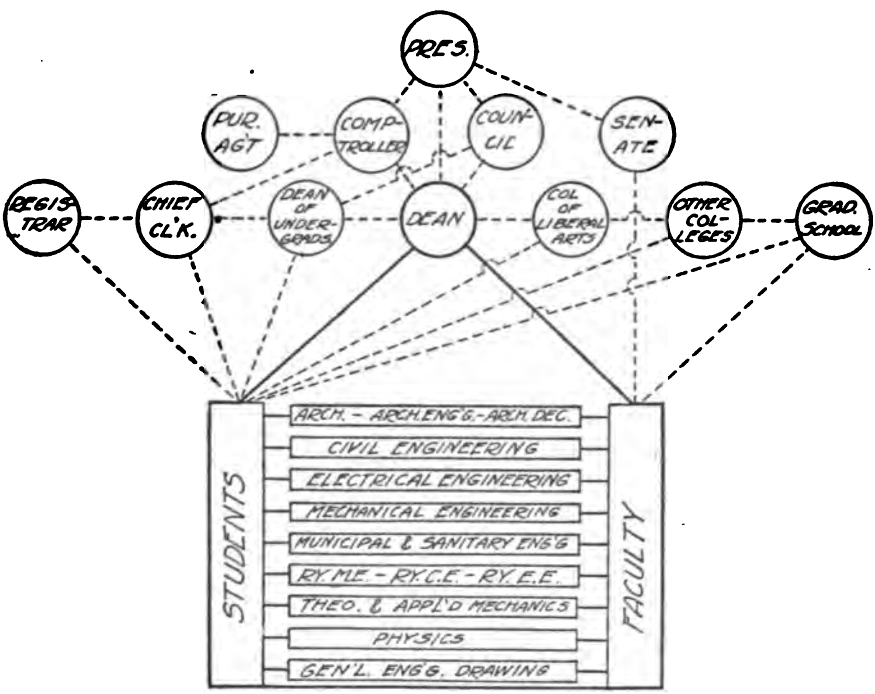
dents therein. It does not, however, have authority to take away from any student any university privilege, nor to do anything trenching upon the executive duties of the dean. It is understood that the college organization is only for convenience within university circles, and that no college shall take action not well supported by rule or usage for which the general officers of the university may be called upon to answer. All matters of general policy, or matters involving the interests of outside parties, are determined by general university authority.

The dean presents the recommendations of his college faculty to the senate, council or president as the case may require, and all official communications from members of his faculty pass to higher authorities through his hands. He is supposed to be an information bureau for both faculty and students with regard to the university statutes, the rules and regulations for the government of students, the program of studies, and all matters pertaining to registration. As the presiding officer of the faculty it is his duty to encourage a free discussion of college policies so that all the members of the faculty shall be competent student advisers. As the executive officer of the college, he makes recommendations for appointments and salaries, is responsible for the methods of transacting department business, approves all requisitions before they go to the purchasing agent, and maintains general supervision over instruction.

The students as well as the faculty should feel the personality of the dean, and he must be alert to see that they are uniformly and fairly treated in all cases. His administrative duties require long office hours and

bring him in contact with the exceptionally strong students and with those who are delinquent. The mass of the average students the dean does not see officially, and he should therefore arrange to meet them socially. He cannot have much time for teaching, but should give at least one course which may be elected by a considerable number of students.

To accomplish the work as outlined here, he must have an assistant whose title may be assistant dean, associate dean, junior dean, or vice dean; a chief clerk to keep the accounts and look after inventories, purchases, etc.; a record clerk to keep the students' records and attend to routine matters pertaining to petitions and study lists; and a stenographer.



SOME PHASES IN THE ORGANIZATION OF STATE UNIVERSITIES.

BY LOUIS E. REBER,
Dean of the School of Engineering, Professor of Mechanical Engineering, Pennsylvania State College.

In the conduct of a university the factor of supreme importance is the quality of its instructional force. The controlling principles that animate the men who originate and shape policies, the high ideals their lives express, their stability and breadth of character, their scholarship and skill in imparting knowledge, their gifts of sympathy and understanding discernment, their power of influencing to finest issues the lives of those about them,—these are the life-currents of the institution. But just as the blood in the human organism ceases to support life when the heart no longer sends its pulse through the system, so no university can exist without a more or less effective physical structure. An imperfect system of organization may be attended by friction which in its influence will pervade the institution, creating disturbances even in the student body, while a well-balanced and wisely systematized organization, like an accurately designed and perfect machine, will run easily and smoothly, with no flaw in the results.

Though it is of necessity a somewhat dry and prosaic study that deals so entirely with the internal machinery of educational life, yet it should prove profitable to devote time to it, in the hope of evolv-

ing a harmonious, simple and consistent working system, so complete and sufficient in itself as to meet all possible requirements and conditions without strain at any point.

It is realized that no system of organization can be devised that will apply to all colleges or universities; that in every institution special conditions must obtain which necessarily modify and frequently control the nature of its organic structure. There are, however, certain fundamental principles underlying the formation of all institutions respecting which some general observations may be made. Time may be devoted appropriately to a discussion of organizations adapted to the needs of that class of institutions known as the Land Grant Colleges, which, from the nature of their foundation exist under like conditions and present essentially similar lines of work.

In order to introduce some phases of the working structure of a state university the following résumé is presented of a system of organization which has recently come under the observation of the writer.

The highest authority is vested in a board of control. Directly responsible to this board is the president of the university who, assisted by a financial agent, a registrar, and a secretary, is the chief executive.

Assume that the university is divided—there being no professional schools, such as law or medicine—into several colleges, their number and work depending upon the scope of the institution of which they form constituent parts.

In the organization of these colleges the dean is

the executive head, directly responsible to the president. The heads of the departments are responsible to their deans, and associate professors, assistant professors, instructors, and assistants are responsible to the heads of their departments.

The deans of the college, with the president of the university as presiding officer, constitute a council of administration; a general faculty composed of the entire teaching force (not all voting) sits upon matters of general legislation, and the college faculties, which include all members of the colleges, act upon purely college interests. A student board, also, is a part of the organization.

As technical knowledge in the various lines of work is essential to the intelligent selection of teachers, this organization provides that the president shall name the deans; the dean shall name the heads of departments with the approval of the president; the heads of departments shall co-operate with the dean in selecting subordinates all to be submitted to the approval of the president. Nominations are subject to the ratification of the board of trustees or a committee representing it, their action as a rule being a formality.

This brief outline of a general plan of organization adapted in its nature to the requirements of a state institution may serve as an introduction to a review in greater detail of effective development of its more important phases.

Board of Control.

The constitution of the board of trustees is in some cases a matter of vital importance to the state university. No uniformity prevails in the methods adopted in different states for the determination of its membership. Sometimes the entire board is appointed by the governor of the state; in others, the members of the board are elected by vote of the people; in others, in part by societies more or less affiliated with practical interests in agriculture and mechanic arts; in others, in part by the alumni; and in still others by several of these methods combined. In some instances, certain state officials are members of the board, ex officio. For example, in Pennsylvania the board of trustees is composed of members appointed by the governor, elected by the alumni, elected by delegates from agricultural and engineering societies, and by virtue of office in the state government.

Perhaps each of these methods of selection has some virtue. Even appointment by the governor of the state, where political expediency sometimes becomes the controlling factor, has decided advantages. In order to secure financial support to the institution, it is absolutely essential that the people of the state acknowledge the Land Grant College as theirs. To promote this end, a certain number of members of the board of control should be appointed by the governor or by the people, or better by both. The writer believes that he may safely assert that the governors of the eastern states have not been influenced largely by politics in the appointment of trustees for edu-

cational institutions. As much cannot be said, however, of several of the western states in which the method of election has been so dominated by politics as to result in a precarious existence for the state institution.

The most *efficient* trustees are frequently those elected by the alumni, from among the alumni. The danger here lies in the harm that may result from a defective method of selection. If wisely chosen, a mature alumnus will in nine cases out of ten exhibit a keener and more sympathetic interest in the institution than could be expected from a member chosen from any other source.

It is doubtless true that, whatever the method of election, an effective board should be a comparatively small one, or that it should be represented by an executive committee of not over five or seven members. Various committees of the board may exercise direct supervision over business or other relations of the institution and thus assume an active part in the executive management. But a strong and efficient college president usually becomes the controlling and dominating force, and the board of trustees is then a less important agent, a fact which a judicious board is not slow to accept.

The President.

The president, as chief executive, is chairman of the general faculty and of the council of administration and ex-officio member of all college faculties. Time precludes discussion in this paper of his duties and powers, further than as they are involved in

the consideration of the other members of the organic structure. The organization outlined assigns to him a specified group of assistants—registrar, secretary, and financial agent. The duties of the registrar differ in different institutions and are more or less important according to the usage in the keeping of records. In some cases, entrance registrations and all other records are kept in the college offices, but usually this work is centered in a main office. This practice recommends itself for its greater convenience and for its economy, as well as in presenting increased possibilities for systematizing the work.

Financial Agent.

By financial agent is not meant the bookkeeper, or chief of the clerical staff, but an officer vested with the purchasing power both for departments and for the working plants. Directly responsible to the president, he in fact represents the board of trustees in the immediate supervision of the financial interests of the university—indeed may be an officer of the board. His duties include first, the purchasing of all materials and equipment; second, the payment of all bills; third, supervision of all accounts, with responsibility for keeping expenditures within the limits of the approved budget; and fourth, the transaction of all general business of the university as assigned to him by the board of control or the president.

So far as his purchasing power for departments is concerned the financial agent is given no controlling authority, except in case the purchase called for in the requisition would overdraw the account, responsi-

bility for the disposition of appropriated funds resting with the deans and heads of departments.

Whether the purchasing power should be centered in one officer, or exercised directly by the department and working plant organizations is difficult to decide. Both methods have earnest supporters. The best modern business practice favors centralization. The success of this policy depends largely, of course, upon the qualifications of the person who holds the office. With the right man in charge, this disposition of the problem of expenditures presents many desirable features. A good college professor is not necessarily a good business man, nor does he have time to spend in attention to the details of a large amount of purchasing which could be done just as well or better by someone else. In the case of the purchase of equipment involving special knowledge or skill a large part of the correspondence relating to its purchase, and possibly personal inspection, must be left to the head of the department or college for which the purchase is made, but the final closing up of the business, payment of the bill, and attention to details of shipment and delivery should not occupy the time of the specialist. It need hardly be said that much of the purchasing can be done to greater advantage in quantity and from a single source.

DEAN.

The position of dean of a college in the university organization is a responsible one, and perhaps one of his heaviest cares is the duty that devolves on him of impressing upon his force of teachers *their* respon-

sibility to the college interests. Although in theory, it is the charge of the department head to mould the spirit of his subordinates, yet the final accountability is with the dean.

It is the writer's experience that a large majority of the younger men who accept positions as teachers expect to give little or no time to the institution beyond the actual hours of instruction and the necessary preparation for it, and in fact not infrequently a man engages in other pursuits and his teaching becomes a secondary consideration. In business young men do not expect to achieve success without giving their whole energy and thought to it, but the college man in a subordinate position must often be taught with long-suffering patience the essential spirit of devotion and personal responsibility. It occasionally proves an exceedingly difficult task to instil effectively into the minds of these men the fact that they are valuable to the institution only in proportion as they make themselves an integral part of it. Though they should be encouraged in engaging in vacation work useful to them for general development, no man of lower rank than that of assistant professor, or possibly of professor, should be permitted to engage in outside business during the university year. It frequently must be impressed upon the younger teachers that they are responsible not only for the mental training of the men in their classes, but also for their instruction in the principles of right-thinking and right-living. If the dean in cooperation with the heads of departments fails in bringing these truths home to every man on the force, he will conclude

either that he has not met his own responsibilities, or that changes must be made in the personnel of the colleges.

In the discharge of his varied and many duties, the dean will unite and coordinate the work of the departments, informing himself as to conditions at home and abroad, in order that his college may keep abreast with the best practices and growth of the times, he will group branches common to all departments under the charge of specialists in the given lines of work, he will suggest and shape new lines of work, support the heads of departments in their relations with students and teachers, act as adviser and councilor to all students of his college, and exercise personal supervision over methods of teaching. He will study every instructor in his college and, taking account of the temperament and early training of each one, will help him to reach his best development, he will remove difficulties where possible or suggest remedies, and if practicable will give to each teacher only that work which he is best fitted to do.

The dean will, especially if in a state institution, identify himself with the societies of his own state whose work has to do with the interests of his college, and if dean of an engineering college, he will become acquainted with the manufacturing, the engineering, and other business enterprises of the state, not only for the purpose of observation, but more important in order to secure their cooperation and support for the university. He will belong, also, to the national societies and attend their meetings when possible in order to enjoy the benefit of association with experi-

enced and thoughtful men whose work is along the same lines as his own.

In the selection of new teachers he will exercise a controlling judgment, assisting heads of departments and conferring with the president. He will settle questions relating to the need for additional instructors, the amounts of salaries and advances called for in salary and position.

In pursuance of his duties as related to the financial affairs of his college, the dean will prepare annually, for the use of the president, an inclusive and detailed budget of expenses necessary for the proper conduct of the work of his college for the coming year. He will pass upon all requisitions made by the heads of departments in the expenditure of sums appropriated for the use of departments. He will formulate in consultation with the heads of departments and present to the president plans for enlargements and increase in the expenditures necessary to the proper growth and development of the college.

Council of Administration.

As advisory to the president and judiciary to the general faculty, the council of administration is an important factor. As has been said, this body is composed of the deans of the colleges with the president of the university presiding. Its powers in some institutions are exercised by the general faculty, a method open to the objection of placing matters of special significance in the hands of a large and general body, instead of under the supervision of a small yet representative one.

The functions of the Council of Administration may be grouped under two main heads, with subheads as follows:

A. Advisory to the president.
1. In the establishment of new lines of work and the inauguration of important enterprises in general.
2. In the preparation of the annual budget.
3. In formulating requests to the legislature.

B. As the judicial body of the general faculty.
1. With jurisdiction in all cases of general discipline which do not come under the authority of the colleges.
2. With power to pass upon new courses of study leading to a degree or changes in existing courses recommended by colleges and to bring these matters before the board of trustees.
3. To consider questions referred to it by any member of the general faculty with reference to college actions and to annul such actions if not in conformity with college regulations, etc.

It will be noted that the Council may prevent the offering of a course leading to a degree which in its judgment does not warrant the degree. It will naturally return such a course to the college from which it originated, with suggested amendments. If these recommendations are accepted by the college and changes made which meet the approval of the council, the course will be submitted to the trustees. By this method the possibility of the introduction of an over-specialized or one-sided course of study is reduced to a minimum. Without the safeguard of some

such body, it is difficult to guarantee uniformity in the requirements of work for degrees, or equitable treatment in matters pertaining to the colleges as related to the university.

What better means can be devised for bringing the president into the close touch with the colleges which is essential to their proper coordination and unification than the introduction of a council of administration composed as specified?

The General Faculty.

The general faculty is substantially a legislative body. Its scope includes questions relating to entrance and graduation requirements, rules and policies for the government of the students who do not come under the authority of the colleges, definition by enactment of the sphere within which the colleges shall have control and, in general, the broader aspects of the educational work of the university. Standing committees composed of representatives from every college, appointed by the colleges, deliberate upon questions relating to advanced degrees, athletics, the library, discipline and morals, entrance requirements, examinations, graduation requirements, military instruction, student organizations and publications, etc. These committees, in addition to their regular duties, should be required to keep informed as to usages in other places, and make annual reports to the general faculty recommending changes.

The general faculty will hold frequent regular meetings, its membership including all persons giving instruction in the institution, only those voting, however, whose rank is above that of instructor.

The College Faculties.

The college faculties shall consist of the entire teaching force of the college and one representative, each, from all the other colleges—this representative to be appointed by his own college faculty or dean. The introduction of an outside member into the college faculty is a mooted point, one which may be open to objections, but the advantages probably outweigh the disadvantages. The acquaintance with general methods obtaining in the different colleges, thus spread among them, must prove helpful in the coordination of their work, and in many cases the knowledge gained by this means of the reasons for special actions must lead to a better understanding. In other words, this practice should tend toward leading the colleges to *pull together*.

The colleges shall be vested with power in the discipline of students while under their instruction and shall make and enforce in consultation with the president all necessary rules and regulations for this purpose and for the transaction of special business not inconsistent with the action of the general faculty.

All courses of study shall be formulated by the college and submitted to the council of administration for approval and recommendation to the trustees.

Much may be said in favor of a strong college organization. Consider, for example, the case of the college of engineering, made up, it may be, of four departments—civil, electrical, mechanical and mining. Their courses of study are so closely and intimately related with so much common and fundamental work that every member of the school must of necessity

have a working acquaintance with them all. In the development of the college the united wisdom of its men must be of the greatest possible value, and it is not fair to subject them to the control of the general faculty of the university, which is composed of a large percentage of members whose training has not fitted them to pass upon engineering requirements.

The general faculty should not be expected to contribute to deliberations relating to specialized lines of work. Loss of time in futile discussions must certainly result from such a course, if not actual perversion of the best interests of the colleges.

The Student Board.

The student board occasionally included in the university organization may consist of two seniors, two juniors, and one sophomore, elected by ballot by the corresponding classes to serve for one year. This board is given the right to appear before the council of administration in cases of discipline, and before the general faculty when matters affecting student discipline or attendance are under discussion. All communications and requests from classes or from the student body to the faculty are submitted through this board. It has no voting power and is not present when votes are taken by the council or faculty. The student board has been tried and found useful in the promotion of that spirit of good feeling and understanding so requisite to successful relations between the governing body and the governed.

THE PART OF SIGMA XI IN SCIENTIFIC EDUCATION.

BY HENRY B. WARD,
Dean of the College of Medicine and Head Professor of Zoology, the University of Nebraska, and Corresponding Secretary of the Society of the Sigma Xi.

When your Secretary wrote me that he had asked Professor E. L. Nichols of Cornell, President of the Society of the Sigma Xi, to present a paper before this meeting giving the ideals and objects of our Society, but had learned to his great regret that Professor Nichols was in Europe, he added: "I consider it is incumbent upon you as Secretary to do everything in your power toward meeting the emergency caused by the absence of the President." Notwithstanding my mild protest and a frank statement of my limitations, in response to his urgency I consented to present as well as possible my conception of the ideals and objects of Sigma Xi.

While an ardent believer in the aims of this organization and in the results it has achieved, I have not enjoyed so long a membership or so extensive an acquaintance in it as to be justified in voicing the sentiments of the Society. I can only give my own interpretation of its work and worth. I should also disclaim any fitness to discuss the special relation of this scientific fraternity to an engineering college. Yet do not we all feel that the principles of science are of universal application, and though working in different and often distant fields, still we are seeking

the same end, the betterment of human welfare, the gradual elevation of the entire human race.

"The name of this organization," reads our Constitution, "shall be the Society of the Sigma Xi; its motto 'Σπουδῶν Ξυνῶνες,' 'COMPANIONS IN ZEALOUS RESEARCH.'"

"The object of this Society shall be to encourage original investigation in science, pure and applied: by meeting for the discussion of scientific subjects; by the publication of such scientific matter as may be deemed desirable; by establishing fraternal relations among investigators in the scientific centers; and by granting the privilege of membership to such students as have, during their college course, given special promise of future achievement."

Only one of these functions outlined by the constitution has not been exercised, namely that of publishing scientific contributions which so far as I know has not been attempted by any chapter. Otherwise general activity has been manifested in furtherance of the objects stated. The various chapters hold from five to nine meetings each year and from three to eight of these have been wholly or partly of a scientific character. Practically every chapter has one or more purely social meetings and also one or more open meetings to which the general public, or at least the university membership, is invited to hear the results of scientific investigations of especial importance for the general welfare.

The membership of the chapters consists of active and alumni members who are defined by the Constitution as follows:

"The active membership of the chapter at any institution shall be composed of such resident professors, instructors, graduate students, and undergraduates as are members of the Society. The alumni membership of the chapter shall consist of former active members no longer connected with the institution, and such graduates as may be admitted to membership under the provision of Sec. 5. . . . Members of any chapter who may become connected with another institution at which there is a chapter shall be entitled to enrolment as active members in the latter."

With regard to the selection of members the Constitution speaks thus:

"The following, and no others, are eligible to active membership in a chapter at any institution: (1) Any professor or instructor of the institution who has shown noteworthy achievement as an original investigator in some branch of pure or applied science; (2) any resident graduate who has by actual work exhibited an aptitude for scientific investigation; (3) any undergraduate in the fourth-year class, or else in the class substantially equivalent thereto, who has given promise of marked ability in those lines of work which it is the object of this Society to promote.

"Any graduate of the institution of not less than five years' standing is eligible to membership on the same conditions as prescribed for professors and instructors."

Under these limitations it is clear that the membership must consist very largely of members of the faculty and graduate students, and some chapters, owing to evident difficulties in selecting seniors on any accu-

rate basis, have become purely graduate organizations. Others, however, elect senior students to membership and this custom is followed most generally and properly in dealing with engineering students since the requirement of a thesis or definite piece of work from all seniors in engineering courses enables one to pass advisedly upon the originality and independence of such students.

Only four chapters have a membership of less than 25; most chapters report 40 to 60 members, while four, Cornell, Yale, Columbia and Chicago, have over one hundred active members. The number of alumni members has grown to more than 600 at Cornell, and reaches a grand total of about 3000 for the entire chapter roll. When one considers also that last year the active membership reached a total of 1350 and that there were added 120 faculty members, about the same number of graduates, and twice as many senior students, or in all about 500 new members, it is evident that the membership of the Society has attained a very respectable figure and is advancing rapidly with each year. While numbers alone do not at all determine the value of an organization, they are none the less an important element in effectiveness and aid in the realization of results which would be beyond the reach of a smaller body.

The relation of the Society of the Sigma XI to engineering is strikingly intimate. Founded at Cornell in 1886, it now has twenty-five chapters. Of these two are at exclusive technological schools, namely Rensselaer and Case; one, Chicago, has no direct connection with an engineering faculty, but the

other twenty-two institutions possessing chapters all engage in engineering instruction and may fairly be said to be among the most prominent institutions of the country offering this line of work. Furthermore the Society was originally established by a few earnest workers in engineering sciences for the encouragement and development of those qualities which the founders deemed of first importance in their own line of investigation. Not only its founders but its present supporters in most if not all chapters include prominently the men in engineering departments. Finally, the convention of 1895 in adopting a policy of extension voted that in awarding a chapter to any institution the number of distinct branches of science represented by full professors should be at least five and that these branches should include engineering. Thus in its origin, in its support, and in the conditions set by it for extension, the society of the Sigma Xi is distinctly associated with engineering education. While it is correct that this feature should be distinctly set forth in a meeting like the present, devoted to a consideration of the problems of engineering education, yet it would be equally wrong not to emphasize the fact that in its influence and ideals Sigma Xi is broader than any one field of science, it aims to work equally in all scientific fields and to exert its influence for the development of all sciences whether pure or applied.

There have been those who have regarded the function of our Society as a purely honorary one. On this point permit me to cite the words of Professor S. W. Williston in his address before the Philadelphia

convention on retiring from the office of national president, "as an honorary society I believe Sigma Xi may do some good, but if it existed for the purpose of giving honors only, it were better never born. To set ourselves apart as better than others, to expose our phylacteries in the public temples is not the object of Sigma Xi, though unfortunately there are those who have thought so."

Sigma Xi is primarily a research society in the broadest sense of the term, and all of its activities are directed toward the accomplishment of this end. By virtue of its relation to the whole field of science it renders valuable service in keeping workers in the diverse fields in touch with each other, and with the investigations in other fields. This coordinating function, though incidental in a sense, is yet exceedingly valuable in contributing to the solidarity of our great institutions of learning, where the more intensive research becomes, the more powerfully each individual line of work tends to draw apart from the rest of the institution. The presentation of the results of research at the meetings of Sigma Xi and the discussions incident thereto act as an evident stimulus to investigation and good fellowship within the limited circle of its own membership. They are equally important in disseminating among the members of the university community a general knowledge of the advance that has been made in scientific fields. Many chapters contribute also to the elevation of science in the university through the celebration of a great scientific anniversary in much the same way that Phi Beta Kappa has been the means of holding regular

literary festivities in our older universities. The annual Sigma Xi address at a number of our larger institutions brings together the university to hear from some man of prominence, the guest and speaker of the occasion, a dignified presentation of the development of research in some particular field. Such an event lends dignity to the Society and also stimulates the whole institution through contact with the men of achievement who are thus brought before it. Every such exposition of any scientific problem by a man of research-power means at least a few converts from credulity to reason, a few brought to regulate habit and action by judgment rather than prejudice, a few moved to take a step into the unknown and by their discoveries add something to the sum of human knowledge and happiness.

In the specific encouragement of research there are several activities of the society which have had marked influence. In spite of criticisms which have been passed in individual cases, yet on the whole care and judgment have been exercised in the selection of members and even the mistakes have not been sufficient to hide the primary object which the society has had in mind. By announcing at the start that in its estimate the research ability is fundamental in importance for the student, it has held up before the institution ideals of the greatest value in counteracting the mercenary tendencies of the day. It has undoubtedly served to arouse some zeal for investigation among the student community and in doing this has pointed out a worthy goal for their ambition.

This constant exaltation of the research ideal has

not been carried out in any narrow spirit. Evidently the possibilities, the directions, and the achievements of research are not alike in all fields, and especially as between pure and applied science radical differences suggest themselves at once. The society has fairly recognized these differences and freely acted in the light thereof. It has recognized that the originality of the engineer, and the highest type of creative power, may be demonstrated in the production of a concrete object rather than, as in pure science, disseminated through the medium of the printed page.

The relations of the Society of the Sigma Xi to scientific education require at least passing mention. President Williston has called it "a larger association composed exclusively of science teachers than exists elsewhere in the world"; certainly its twenty-five chapters with nearly 1500 active members, which are made up almost entirely of the teaching staff in the broad sense, justify this statement; and when heads of departments, professors of various grades, instructors, fellows, scholars, assistants, and those about to enter upon technical careers, come together in its meetings on terms of fraternal equality, the problems of the institution cannot fail to be at least quietly discussed and indirectly influenced for the general good of the educational results. The furtherance of research is the advancement of scientific education at its highest point and rests back ultimately upon the satisfactory development of the student by the educational experiences through which he has passed. Thus Sigma Xi is vitally interested, and though not exercising as yet any definitely directed

influence upon educational problems, no one can doubt the tremendous force of its silent influence.

Sigma Xi was founded to encourage research, the restless inquiring spirit of to-day that hardly existed yesterday and was unknown the day before. This is the progressive factor in modern life, the search after truth that drives a student out beyond the limits of to-day's knowledge into the vast realm of the unknown to find some fragment of the philosopher's stone, to add some bit, however small, to the great temple of knowledge which men of all lands and ages are slowly rearing as a monument to human intellect: in its unfinished form a delight to the mind of man to-day and tomorrow until time shall cease and truth be complete. Not every man may take part in this work; many a one who was known as a scholar and a man of culture has left no trace of his handiwork on this temple of knowledge. Many men make good soldiers who never become leaders; many students follow successfully as far as they are led and assimilate the intellectual food placed before them without producing energy enough to go in independently and become productive, constructive factors in the intellectual world. It is the function of Sigma Xi to search out this productive faculty, to stimulate its possessor to further inquiry that all such individuals shall contribute through investigation their maximum effort to the extension of the limits of knowledge.

This creative power is a fundamental characteristic of the human species, it is the keystone of progress. On its development hang alike the past and the future of mankind. Whatever stimulates originality and

research contributes to the advance of the whole human race. Mental inertia and intellectual ease tend to influence men to follow beaten paths, yet advance can only be made by the work of those who are willing to strike out into the unknown and strive to accomplish that which has never yet been achieved. Among the leaders in this movement to add to the sum of human knowledge and achievement, the engineers stand in the forefront. They have contributed at a thousand points to the comfort, safety and effectiveness of modern life and they are to contribute even more largely to the fuller life of the future. But just because they are doing this, and because the world has need of even greater help from them, does it become necessary for them in education to avail themselves of every influence which can be mustered to assist in the development of originality, to nurture the spirit of investigation, to arouse the creative power. The Society of the Sigma Xi may justly claim to be such an agency, and as such to have a rightful place in institutions for scientific education.

THE PLACE OF THE INTERCOLLEGIATE SCIENTIFIC FRATERNITY IN AN ENGINEERING COLLEGE.

BY EDWARD H. WILLIAMS, JR.,
Founder of the Tau Beta Pi Association, and Sometime Professor of Mining Engineering, Lehigh University.

Technical courses have always been handicapped by lack of time and opportunity. The illogical demand that men shall be considered graduated and fit for serious work before their frames have stopped growing, and while their muscles and brains are in a vealy condition, has shortened the time of study in both fitting school and college—turning the former into a period of cramming dependent upon strength of memory, rather than assimilation following digestion, and forcing the course of study in the latter to a mere skeleton of necessary studies, more or less garnished by others which may or may not be useful.

The technical graduate is becoming more and more like his European brother in being a specialist, good in one thing and worthless in all else. He is further handicapped by a lack of broad culture which furnishes abundant food for thought, and which permits him mental recreation outside of his peculiar trade. We are all so thoroughly convinced of the present narrowness of technical work that we are trying a number of schemes to add breadth and prevent the tendency to work into a rut that now obtains.

There is another fault in a hasty scheme of study, and one of such magnitude that it should be met and

eliminated. I refer to the cultivation of originality. With the exception of the thesis and a few "original problems" there is little in the average course that fits a man for grappling with unusual conditions, so that the graduate has to learn his limitations at the expense of the public, and of his own reputation. Sometimes he never learns and is satisfied with being a creature of routine; now and then his mistakes obtain the magnitude of a calamity, if not a crime.

In almost every technical college there are one, or more, "engineering" societies. Some are given wholly to the government of undergraduates and, like all college affairs in such hands, are characterized by irregularity in strength, in interest, in value; others are shouldered by members of the faculty, who galvanize the moribund body into activity by periodic suppers. All are without continuity in interest, and in none of them is there sufficient attraction to cause the student returning after vacation to look forward to work therein with eagerness. In the majority of cases the work is mediocre and perfunctory.

The technical graduate is unfortunate in being generally without a knowledge of culture studies, and too frequently his command of his native tongue is so inadequate that his theses are painful to contemplate and his after-dinner speeches, a weariness and tribulation to the listeners. And yet we do not see that we have sent him into the world to call its attention to what are sometimes splendid abilities, and have handicapped him as effectually as if he were a deaf mute. How frequently a grand scheme has been turned down because its originator has been unable to fully explain

it, or even to hold the attention of the powers that be. Technical graduates are too frequently handicapped by more than youth and inexperience.

The technical teacher is unfortunate in having to acquire at second-hand the information that keeps him abreast of his work. We can count on our fingers the men who are fortunate in having private laboratories and abundant leisure for research work. It requires a judicial and penetrating mind to properly value methods reported in periodicals, where the statements are full and the period during which the method has been employed is sufficient to expose the seamy sides. Too frequently, however, the reporter is handicapped by inexperience and takes for granted whatever statements fall from the mouths of interested parties. Too frequently we read only of the machine which is to do certain work, and can study its construction; but we never learn of its failure, wherever tried, until we have used it in class-work as an example.

Finally, we send out into the world with diplomas all who pass above a given standard, and generally certify that each one of them is as capable as the others, in that all the diplomas read alike. I remember congratulating a valedictorian twenty-three years ago with having his diploma. He thanked me and replied in his slow drawl, "B.'s got one too." B. was an unfortunate who had failed in almost every examination, and by sheer force of memory had been able to scrape through with a passing mark. This started a train of thought as to the right of a college to send a man into the world as a civil engineer, for example, when he could never be trusted with any-

thing more valuable than the front end of a chain. I have had so many letters from employers who asked about qualities in applicants, and when I would write that A. could be trusted with any kind of work, B. would be only good at routine, and C. must be watched and checked, I felt how necessary it was that a diploma should fully tell a man's character. The chief engineer of a well-known road once asked, "What sort of a man was D. in college?" After telling him, I asked why he put the query, and received the line "He can't add." Happily a tunnel caved in upon him soon after and removed him from the humdrum life that awaited him.

Soon after the conversation with the valedictorian, mentioned above, the writer determined to start a movement for bettering the conditions just given, by trying to break down the walls between faculty and students, and forming a sort of "Clearing House" where the best of the undergraduates could meet their teachers in a social manner, and where continuity of work could be looked for by associating classes in a manner to do away with class distinctions and class antagonism. With this would come a recognition that the men so engaged were of creditable standing and of selected ability. Lastly, all so chosen must be of good character.

An ordinary society would never attain these ends, as shown by the wrecks so thickly strewn along the past, and an element of secrecy—nothing more than the reticence observed in family life—was thrown over the undertaking, and to its support the leaders in previous classes were invited. All accepted gladly

and thus about a quarter of a century ago, at Lehigh University, the Tau Beta Pi Society was organized. To-day its elections are desired more than any other university success, and at its meetings the president of the university, the heads of the different departments, the alumni in the vicinity and the selected undergraduates meet for friendly conversation on a common plane, where age and position are forgotten and all are animated by one spirit, the betterment of the university.

From this parliament the undergraduates go to their work with a broader idea of their opportunities and a more realizing sense of their responsibilities. In college meetings their voices are on the side of soberness and common sense. Lehigh has been for more than a generation without dormitories, and its students have probably a greater freedom outside of the classroom than in most institutions. Since the success of this society, there has been a strengthening of a feeling of responsibility among undergraduates, and in no institution does the Student Court follow up cases of irregularity in classroom and examination work with greater vigor, or impose sentences of greater weight.

Of course all of the change is not due to the work of this society; but it has leavened the students so that there is more of a feeling that recitation rooms are places for consultation rather than where obvious questions are asked and answered in a perfunctory manner; the members of the faculty know intimately the best men in the class and can call upon them in a manner which elevates the class standing and vivifies the atmosphere.

This movement has been thought worthy of adoption in a dozen or more technical institutions, and has been more or less successful wherever tried. An unpretentious periodical is issued regularly, and in the various reports there is evidence of something more than the ordinary interest in professional matters.

The fact that there is something valuable in the society is shown by the interest taken by the faculty members in its meetings, and the fact that it has maintained an existence of a quarter of a century without disclosing points of weakness seemed of sufficient importance to warrant this brief note.

THE TAU BETA PI ASSOCIATION.

BY R. C. MATTHEWS,
Secretary of the Tau Beta Pi Association, La Salle, Ill.

Professor Williams has told you of the causes which led to the formation of the Tau Beta Pi Association, of the ideals he set before it, and of his aspirations for its growth and usefulness. It will be my attempt to show you to what extent the society has confirmed his faith in its future, and to present a few details regarding its present condition.

As is usually the case with college societies, the initial extensions of Tau Beta Pi were due to the personal efforts of members of the parent chapter who went to other institutions as instructors. Professor L. P. Breckenridge, who is an honorary member of the Lehigh chapter (the first, by the way, ever initiated), went to Michigan Agricultural College, and it was not long after his arrival that the second chapter was established in 1892. Professor J. J. Flather was instrumental, under similar circumstances, in securing in 1893 a chapter at Purdue University. Other chapters followed, the growth being slow at first, as the number of members going to other colleges was small; but as the membership increased, more teachers went out, and of late years the society has been more rapidly extended. There are now eighteen chapters, which have initiated nearly 2500 members.

These chapters are established only in colleges having technical departments. In nearly all cases the membership is limited to engineering students. In one or two cases only, a small proportion are drawn from the courses in pure science.

The government is vested in an executive council of four members, three of whom are elected at the annual convention to serve three years, one being elected each year. All members are chosen from among the graduates. These three elect a fourth as permanent secretary of the association, in whom is vested the business management of the society, and who keeps the records. By making the secretary more or less permanent, the hiatus which usually results from the transfer of records and the unfamiliarity of the new officer with his duties, is avoided.

A comprehensive constitution provides for the conduct of the society. It is not secret. A printed copy is furnished to each member.

Membership is of two classes, regular and honorary. Regular members are chosen as follows: The student who has maintained the highest scholarship in the class up to the beginning of his junior year, is eligible to election at that time. The remainder of the highest one-eighth of the class becomes eligible at the beginning of the second term or semester of the junior year, and the second eighth is eligible at the beginning of the senior year. The method of determining the grade of scholarship varies in the different chapters. In some, where numerical grades are given, the averages of these are strictly adhered to as determining eligibility. In others where no numerical grades are given, the elections are made

from the proper number of students recommended from the standpoint of excellence in scholarship, by a committee of members of the faculty. In all cases the members must be elected by ballot, and each must receive the favorable votes of three-fourths of those present. It is thus apparent that elections are not automatic, depending only upon high scholarship, but that character as well receives due consideration.

Regular membership is also offered to alumni of the college who graduated before the chapter was established, and who would have been eligible under the conditions just mentioned if the chapter had existed prior to their graduation. Many chapters number among their members alumni of this class. It is a cause for congratulation that these "old boys" are quite generally in the heartiest sympathy with their chapter, and are always ready to do their best for its members and for the association at large.

Graduates of the institution in which the chapter exists, or of similar institutions, distinguished by reason of attainments in their profession, may be elected to honorary membership. A quarterly magazine, called "The Bent," has just completed its second year. It has been published heretofore by the Pennsylvania Alpha chapter, but is to be conducted in the future by the Executive Council.

A catalog of the membership was published in 1898, and another edition is in preparation.

The badge of the association is a gold watch-key, shaped like the bent of a trestle. This badge, also known as the "bent," and an engrossed certificate of membership stating his qualifications, are presented to each member at his initiation.

So much for the progress and condition of the society. Let us now see what are its rights to exist, and upon what its claims for consideration are based.

During the initiatory ceremonies and throughout the chapter life, especial stress is placed upon the member's loyalty to his alma mater. He is encouraged to work for his college both as a student and as an alumnus. His obligation to support his college in return for the equipment for life's battle which he has received is made plain, and his efforts for its improvement and progress are enlisted. A prominent place is also given to the obligation his past attainments place him under to maintain his high standards, not only during the remainder of his course, but also during his professional career. That these aims are realized, the high standards prevailing among the alumni, and the unvarying spirit of loyalty to alma mater which they possess bear emphatic witness.

Professor Williams has described the cordial relations existing between faculty and students at Lehigh, and his remarks apply equally as well to other institutions where chapters of this association are found. In all there is a spirit of hearty cooperation, which, while not confined by any means to Tau Beta Pi circles, owes a large portion of its origin to that source, and is maintained as a valuable influence by the society's efforts. We, as instructors, well appreciate what it means to have men in our classes who can always be depended upon to handle their work intelligently. The members of Tau Beta Pi are usually of this sort, and we can always rely upon their assistance and support in matters of class discipline or college welfare.

In broadening the equipment and character of the members, in teaching them to speak and write correctly, through experience in the meetings, the several chapters proceed differently—their methods depending upon local conditions. Many have literary programs as prominent features of the meetings, while others devote them to business and social ends alone. In some cases the chapter arranges and maintains a lecture course, engaging speakers prominent in engineering lines to speak before meetings of the students at large. Where the literary phase does not receive much attention, it will generally be found to be the case that the members of the chapter are the moving spirits in the administration and support of the engineering societies of their various departments, and that their interest keeps these organizations at a high state of efficiency. This is particularly true at the larger colleges, where technical societies are more likely to be strong. Certain chapters carry on some organized work of general benefit to the college, such as gathering certain statistics. This phase of activity has not received the attention which many of us believe its possibilities merit, and it is our opinion that a great field for valuable work here exists.

Tau Beta Pi is essentially an undergraduate organization, and among its active members and alumni the fraternal feeling is well developed. In these respects it differs somewhat from the other honorary societies now existing. From the nature of its conditions of eligibility, a considerable proportion of its members are likely to be men who have devoted themselves perhaps too closely to their studies, and special at-

tention is paid to the promotion of good-fellowship, and to the development of the members along social lines. Tau Beta Pi conflicts in no way, however, with the regular social fraternities. Its members are elected entirely from the junior and senior classes, while the fraternities rarely elect men later than their sophomore year. Elections to Tau Beta Pi are just as highly prized among fraternity men as among others, and they make just as loyal members of the society in most cases. In the past the association has been rather noted for its severe initiations, and has had the reputation of being worse in that respect than any other college body. At the ninth convention, however, it became evident that a strong sentiment against this sort of thing existed, and the convention adopted a resolution opposing further "horse-play" and roughness in the initiations, as derogatory to the dignity of the body.

While the fraternal sentiment is fostered during undergraduate days, an effort is also made to keep the alumni in touch with each other, by organizing alumni associations wherever a sufficient number is found. Banquets, in connection with local chapters, or independent of such, afford frequent opportunities for the extension and renewal of acquaintance among members of the profession.

The Tau Beta Pi Association benefits the undergraduate by instilling high ideals and lofty standards of professional ethics. It brings together the brightest men in the college under a common bond, and fosters friendships that count for something in after years.

To the college itself the association soon becomes of marked benefit. In addition to promoting college loyalty, and making closer the relations between faculty and students, the establishment of a chapter invariably raises the standards of scholarship. In every college the students are exceedingly anxious to receive elections to the society, and many instances are known where men begin their efforts early in their freshman year, with the attainment of the honor of election in view.

To a considerable extent Tau Beta Pi is interested and working along the same lines as the Society for the Promotion of Engineering Education. While the greater benefit results from the consultation and deliberations of instructors from the various colleges, it is exceedingly desirable, and in fact essential to the successful introduction of progressive methods, that we have the support of at least the leaders of the student body. To the chapters of Tau Beta Pi we may look for this support, with the assurance of receiving it. The writer has wondered if it is not desirable that closer relations should exist between our society, and this earnest, conscientious body of engineering students. *We* are working to increase the efficiency of *their* equipment for facing the responsibilities of life and their profession. *They* are working to make the best use of the facilities we afford, and to reflect credit upon us by their success. Our interests are supplementary, if not identical, and, in the writer's estimation, only good can result from a direct effort toward definite cooperation between the Tau Beta Pi Association and the Society for the Promotion of Engineering Education.

A COURSE IN PHYSICS FOR ENGINEERING STUDENTS.

By W. S. FRANKLIN,
Professor of Physics, Lehigh University.

There is too much of a tendency in our technical schools to curtail elementary instruction in the sciences, and to expect our students to get a general insight into elementary physics and chemistry by a study of the more elaborate technical subjects which rest upon these sciences. This is exemplified in the degree to which courses in elementary mechanics and heat are abbreviated in our schools and by the inclusion of what are intended to be advanced courses in applied mechanics and thermodynamics of a great deal of elementary instruction. The objections to this arrangement are, first, that the elementary aspects of a subject are almost sure to be obscured by the excess of detail that is always involved in the advanced courses, and second, that the more advanced instruction is nearly always given without an accompaniment of laboratory and lecture demonstration work of the kind that is required to accentuate the fundamental principles of the subjects.

Character of Instruction in Elementary Physics.— We are now passing through a formative period in the establishing of a satisfactory course in elementary physics for technical students, and it seems that there are three questions in particular which are now up for solution: First, as to a clearer line of division

between instruction in the elementary sciences and in the applied sciences; second, as to the character of the instruction in the elementary sciences and third, as to the time to be devoted to elementary physics and chemistry in our technical schools. Many engineering instructors feel that present courses in elementary physics are more or less ineffective, and we see evidences in a number of institutions of an attempt to rectify this matter by the establishment of professorships of physics especially for engineering students. Many of our teachers of physics are certainly inclined to turn away from the exacting method of presenting this subject, and to lean towards a popular presentation in which the striking phenomena and the fascinating descriptive phases of the subject are allowed to monopolize the attention of the student. An exacting mode of presentation must eventually prevail, and too much stress cannot be laid upon the development of the simpler parts of physical theory and upon a thorough drill in numerical calculations.

In the teaching of physics a clearly and concisely written text-book should be used; explanatory lectures of such character as to appeal properly to the student's imagination should be given, theoretical lectures in fact, illustrated by the simplest kind of experiments; the student should be required to perform a large amount of numerical calculation; and he should be provided with laboratory work from the beginning to the end of the course.

Time to be Given to Elementary Physics.—Two full years of work in elementary physics is not an unreasonable amount to include in our technical courses.

In the first year, one lecture and two recitations every week and one laboratory period every two weeks should be devoted to mechanics and heat. In the second year, one lecture, two recitations and one laboratory period per week should be given to electricity and magnetism and to light and sound. The laboratory work of the second year should, however, consist in part of a continuation of the work in mechanics and heat.

Elementary Mechanics.—Effective instruction in elementary mechanics, with emphasis upon the physical aspects of the subject, is the most important element in technical education. Without this firm foundation nothing can be accomplished in the other branches of physics, and but little can be done in any other line of technology. A detailed discussion of the teaching of elementary mechanics is given in a paper to be presented at this meeting. An outline of a suggested laboratory course in elementary mechanics is given at the end of this paper.

Heat.—So far as one is able to judge, it seems that problem work in elementary physics is too much confined to mechanics, not, indeed, that the amount of problem work in mechanics is greater than might be desired, but that the possibility of problem work in heat and perhaps also in electricity and magnetism is unduly limited thereby. At one institution, for example, provision is made for about five and a half term-hours of problem work in simple statics and in the dynamics of translatory motion, and but one-half of a term-hour is available for problem work in the dynamics of rotatory motion, elementary elasticity,

hydrostatics, hydraulics, thermometry, calorimetry, and changes of state. Criticism is unnecessary. Thorough instruction in heat is quite as important as thorough instruction in elementary mechanics.

Instruction in heat should cover the following topics: thermometry; calorimetry; changes of state; conduction, convection and radiation; the properties of gases; and a simple discussion of thermodynamics. The fundamental ideas of thermodynamics might be insisted on as the rational essence of the whole subject of heat. Some of our deepest-seated physical intuitions can, by a proper suggestive handling of them, be transformed into the rational structure of thermodynamics, so as to give to the second law (often spelled with capitals because, perhaps, nearly every one remains unconvinced) the same unquestioned dominion over every physical argument that is now universally conceded to the first law of arithmetic, namely, that two and two are four.*

Electricity and Magnetism.—It is high time for some one to undertake to develop the logical structure of this branch of physics in contempt of the tremendously over-emphasized system of absolute measurements. Not one student in a hundred ever gets a clear idea of that long chain of ordered operations which forges the ampere out of the meter, the kilogram, and the mean solar day; indeed, every electrical engineer ignores this chain of operations on the recommendation of several International Congresses and defines his ampere as so much silver-plating per second, by the watch!

* See a brief paper on "The Intuitive Aspects of the Second Law of Thermodynamics," *Electrical Review*, September 8, 1906.

That part of the subject of electricity and magnetism which precedes the ampere is always a nightmare, and the subsequent development of the subject, which is as simple and concrete as one could wish, is spoiled. I have held more than one serious argument to justify what seems to be to some extent a teaching innovation of mine in beginning the teaching of electricity and magnetism at the *electric-current end* rather than at the *electrostatics end;* and yet I know of but one electrical engineer who has clear ideas of the more or less obscure phenomena that like a mist surround the electrostatics end of the subject, whereas every school boy has some substantial knowledge of the electric current. When will we learn to teach physics according to our doings?

Elementary laboratory work in electricity and magnetism has heretofore been limited to too narrow a field, and it is very important that the experiments be chosen to cover as wide a range of phenomena as possible.

Light and Sound.—Very little need be said regarding the teaching of this branch of physics except to insist on the importance to any engineer of a clear understanding of optical instruments and of some understanding of the phenomena of wave motion and oscillatory motion, which are nowhere so prominently exhibited as in the phenomena of light and sound.

Laboratory Course in Elementary Physics.

Mechanics.

First year. One period every two weeks.

1. Practice with the simple vernier, use of vernier caliper and barometer.

2. Use of micrometer caliper, spherometer, and micrometer microscope.
3. Use of the balance.
4. Standardization of measuring vessel and determination of specific gravity.
5. Use of hydrometer, use of Jolly's balance, specific gravity by Hare's method.
6. The ballistic pendulum.
7. Determination of center of mass.
8. Efficiency of differential pulley and tackle block.
9. Power developed in climbing stairs.
10. Efficiency of a water motor.
11. Study of sliding friction.
12. Study of harmonic motion.
13. Verification of Boyle's law and calibration of the pressure gauge.
14. The Venturi water meter.
15. Determination of the density of gases by method of efflux.

Mechanics and Heat.

First half of second year. One period every week.

1. The use of the cathetometer and of the comparator, measurement of length by the reading telescope.
2. Eccentricity errors of a divided circle, the reflecting goniometer, the optical lever.
3. Time by eye and ear and by the chronograph.
4. Moment of inertia by gravity pendulum and by torsion pendulum.
5. Elastic constants by tension, flexure and torsion.
6. Surface tension of water, viscosity of a liquid.
7. Thermal expansion of a glass vessel.

8. Vapor pressure curves, hygrometry.
9. Curve of cooling.
10. Specific heat determinations.
11. Latent heat determinations.
12. Clement and Desormes' method for specific heats of air.

Electricity and Magnetism. · Light and Sound.

Second half of second year. One period every week.

1. Comparison of magnetic field intensities by oscillations.
2. Use of tangent galvanometer.
3. Use of the slide wire potentiometer.
4. Use of the slide wire bridge.
5. Use of the box bridge.
6. Efficiency of an electric motor.
7. The water coulombmeter. (Standardization of an ammeter by electrolysis of sulphuric acid.)
8. Chemical efficiency of a voltaic cell.
9. Standardization of a ballistic galvanometer.
10. Comparison of capacities by ballistic galvanometer.
11. Dip of earth's magnetic field by ballistic galvanometer.
12. Distribution of flux along a magnet by ballistic galvanometer.
13. Measurement of inductance by ballistic galvanometer.
14. Charge and discharge curves of a condenser.
15. Determination of dielectric strength.
16. Radius of curvature of a concave mirror by reflection.
17. Measurement of focal lengths and determination of indices of refraction.

18. Study of chromatic and spherical aberrations, and astigmatism.
19. Magnifying power of microscopes.
20. Magnifying power of telescopes.
21. Spectrum analysis.
22. Photometry.
23. Use of polariscope.
24. Velocity of sound by Kundt's method.
25. Determination of pitch by a resonating air column.

(For discussion, see page 335.)

THE TEACHING OF ELEMENTARY MECHANICS.

BY W. S. FRANKLIN, Professor of Physics, Lehigh University,
AND BARRY MACNUTT,
Assistant Professor of Physics, Lehigh University.

All undergraduate instruction in science, especially the brief courses in science which are offered in our B.A. courses should relate chiefly to practical applications. "We advise all men," says Bacon, "to think of the true ends of knowledge and that they endeavor not after it for curiosity, contention, nor the sake of despising others, nor yet for reputation or power or any such inferior consideration, but solely for the occasions and uses of life." It is impossible to imagine any other basis upon which the study of physics can be justified than for the occasions and uses of life. At any rate, nearly the entire subject-matter of physics now relates to the conditions which have been elaborated through the devices of industry, and it is ridiculous to attempt to engage any young student in the study of obscure physical phenomena in the face of the increasingly obtrusive phenomena of practical mechanics, and steam, and electricity. Let it be understood that physics is the study of actual physical things and not by any means a weakly speculative branch of philosophy.

From this practical point of view, it may seem that physics should be studied in the shop rather than in the school, and indeed, if this were feasible, it would perhaps be the best possible thing. But what is the

science of physics? That is the question. One definition, at least, we must repudiate. It is not the "science of masses, molecules and the ether." Bodies have mass and railways have length, and to speak of physics as the "science of masses" is as silly as to define railroading as the "practice of lengths," and nothing as reasonable as this can be said in favor of the conception of physics as "the science of molecules and the ether"; it is the sickliest possible notion of physics, even if a student really gets it, whereas the healthiest notion, even if the student does not wholly grasp it, is that physics is the science of the ways of taking hold of things and pushing them.

Bacon long ago listed in his quaint way the things which seemed to him most needful for the advancement of learning. Among other things he mentioned "A New Engine, or a help to the mind corresponding to tools for the hand," and the most remarkable aspect of physical science is that aspect in which it constitutes a realization of this New Engine of Bacon. We continually force upon the extremely meager data obtained directly through our senses, an interpretation, which in its complexity and penetration, would seem to be entirely incommensurate with the data themselves, and we exercise over physical things a kind of rational control which transcends the native cunning of the hand. The possibility of this forced interpretation and of this rational control depends upon the use of two complexes; (*a*) a logical structure, that is to say, a body of mathematical and conceptional theory which is brought to bear upon the immediate materials of sense, and (*b*) a mechanical structure, that is to say,

either (1) a carefully planned arrangement of apparatus, such as is always used in making measuremnts, or (2) a carefully planned order of operations such as the successive operations of solution, reaction, precipitation, filtration, and weighing in chemistry.

These two complexes do indeed constitute a New Engine which helps the mind as tools help the hand; it is through the operation of this New Engine that the interpretations and control of the physical sciences are made possible; and the study of elementary physics is intended to lead to the realization of this New Engine, (1) by the building up in the mind of the logical structure of the physical sciences, (2) by training in the making of measurements and especially in the performance of ordered operations, and (3) by exercises in the application of these things to the actual phenomena of physics and chemistry at every step and all the time with every possible variation.

Many raise the objection that a rigorous presentation of the structure of physics, logical and mechanical, is highly unsatisfactory and uninstructive, and of course this is true if the physical facts themselves are lost to view; but any student who wishes to indulge a fancied interest in the "results" of science should be treated honestly and placed under the instruction of Jules Verne where he need not trouble himself about foundations but may follow his teacher pleasantly on a care-free trip to the moon or with easy improvidence embark on a voyage of twenty thousand leagues under the sea.

The most important function of the teacher of physics is to build the logical and mechanical struc-

ture of the science; the logical structure mainly by lecture and recitation work; and the mechanical structure mainly by laboratory work. These two aspects of physics study should run along together.

One great difficulty in the teaching of physics is that the native sense of most men is incapable, without stimulation, of supplying the materials upon which the logical structure of the science is intended to operate.

Another difficulty is that the human mind, intuitively habituated as it is to consider the immediate practical affairs of life is turned with great effort to that minute consideration of apparently insignificant details which is so necessary in the scientific handling of even the most distinctly practical problems.

A third difficulty, which indeed runs through the entire front-of-progress of the human understanding, is, that mind-stuff, which has been developed as correlative to certain aspects of our ancestral environment, must be rehabilitated in entirely new relations in fitting a man for the conditions of civilized life, and every teacher knows how much coercion is required for so little of this rehabilitation.

A fourth difficulty is that the possibility of rehabilitation of mind-stuff has been developed as a human faculty almost solely on the basis of language, and that it expresses itself almost entirely in the formation of ideas, whereas a great deal of our knowledge is correlated in mechanisms and can scarcely be reduced to verbal forms of expression.

The best way to meet this quadruply difficult situ-

ation is to relate the teaching of physical science as much as possible to the immediately practical things of life, and, repudiating the repugnance which most of us feel for "literary style" in the handling of what we proudly call the "exact sciences," go in for suggestiveness as the only way to avoid a total inhibition of the little sense that is born with our students. "Our method," says Bacon, "is continually to dwell among things soberly without abstracting or setting the mind farther from them than makes their images meet," and "the capital precept for the whole undertaking is that the eye of the mind be never taken off from things themselves, but receive their images as they truly are, and God forbid that we should offer the dreams of fancy for a model of the world."

Real Knowledge of Mechanics.—We do not disagree with Professor John Perry in his belief that "boys are so uneducated at present that for one of them to learn mechanics is almost miraculous," nor do we differ with him in so far as we understand his point of view, in what he means by "a knowledge of elementary mechanics." Surely, as Professor Perry says,* a boy who passes so easily the ordinary examinations in mechanics and so quickly answers questions concerning, for example, the behavior of unequal weights slung by a perfectly flexible cord without weight over a frictionless pulley without mass, does not necessarily have the knowledge above referred to. He remembers a few formulæ, but he

* See discussion on the Teaching of Elementary Mechanics at the Johannesburg meeting of the British Association, 1905, edited by John Perry, London, 1906.

may have no comprehension of the simplest mechanical principles, and when he forgets the formulæ, as he generally does very quickly, he forgets everything and dislikes the thought of mechanical theory.

Many of our teachers and examiners show a very decided impatience towards those who talk vaguely of a real knowledge of elementary mechanics as of something altogether uncommon, and perhaps we should demand of the practical man that he define more completely what he means thereby, but so far as we know, no one has gotten any further than to define it as a sort of intuition. Yet everyone must recognize the existence of a mechanical faculty, which in some individuals, at least, is remarkably developed, and very many of us despair of ever being able to give to our class-work in elementary mechanics that intimate character which it must have if it is to develop effectually this intuitive mechanical knowledge. Indeed, real knowledge of elementary mechanics, as of any other branch of physics, seems to be nothing more, and it is certainly nothing less, than our deepest-seated intuitions transformed into a logical structure which makes actual connection with things, and which cannot by any possibility be forgotten or fall into disuse.

Those modern studies in psychology which have brought to light the so-called marginal regions of the mind have surely an important bearing upon this question. All elemental knowledge such as the knowing how to throw a ball, how to ride a bicycle, how to swim, or how to use a tool, seems to be locked in these marginal regions as a very substantial but very

highly specialized kind of intuition, and the problem of teaching elementary mechanics is perhaps the problem of how, by suggestion or otherwise, to drag this material into the field of consciousness where it may be transformed into a generalized logical structure having traffic relations with every department of the mind.

A formal and abstract treatment of the principles of elementary mechanics tends more than anything else to inhibit the influx of this elemental knowledge from the marginal regions of the mind into the field of consciousness, and results in the building up of a theoretical structure which can have no effectual traffic with any mental field beyond its own narrow boundaries. Such a state of mind is nothing but a kind of idiocy, and to call it knowledge of mechanics is silly scholasticism.

What is needed is a mode of presentation of elementary mechanics in which the precise aspects of the subject are frankly treated as *ideas* and not as physical realities, the whole being arranged on a background of suggestiveness that is calculated to stimulate the marginal regions of the mind and thereby establish such connection as our minds are capable of with actual physical reality.

An amusing illustration of the presentation of the precise aspects of elementary mechanics as physical realities and not as ideas is furnished by the following incident, which occurred in the class-room of one of our best teachers of mathematics, who is charged also with the teaching of elementary mechanics. The subject of projectiles being up for discussion, a

rather stupid student was called sharply to account with the question "What is a projectile, anyway?" "Would you be a projectile if I were to pitch you out of the window?" "Yes," replied the young man, hesitatingly; and he was met with the instant response, "No, you wouldn't; a projectile is a material particle." Now, a material particle is nothing but an idea. We may speak of any body as a material particle when we are concerned with its translatory motion only, to whatever extent the body may perform other movements at the same time, such as movements of rotation and oscillation. Most assuredly, a young man pitched out of a window would be a projectile, and his gyratory motion would not limit the applicability to him of the *idea* of a material particle, any more than would the obscure commotion which would certainly spread through his system in the form of overwhelming fright.

It is very desirable, however, to express ideas in objective terms as if the ideas existed physically; thus we speak of a material particle, of a rigid body, of the perfectly elastic solid, of the frictionless incompressible fluid, of the perfect gas, of the atom, of the molecule, and so on; but this objective form of expression is apt to bring about that confusion of boundaries between our logical structures and the objective realms of reality, which, according to Professor Münsterberg, is the greatest danger of our time. And yet one must not lose sight of the tremendous advantage in the imparting of ideas which comes from the dressing up of the ideas in objective terms, for, as Helmholtz says, "it is a great advantage for the sure understanding of

all abstractions if one seeks to make the most concrete possible pictures of them, even when the doing so brings in many an assumption which is not strictly necessary."

Scope of Elementary Mechanics.—The apparently widespread tendency to narrow the instruction in elementary mechanics to the topics of simple statics and the dynamics of translatory motion, a tendency which is largely due to the introduction of an excessive number of more or less artificial and fanciful problems, is deplorable. The subject of elementary mechanics should cover simple statics; simple measurement; the dynamics of translatory motion, including circular and harmonic motion; the dynamics of rotatory motion, including a fairly complete discussion of precessional rotation; friction and energy; elasticity (statics); hydrostatics; hydraulics; and wave motion and oscillatory motion.

1. As to the importance of measurement, it seems to us there can be no doubt. A student must know how to measure the various mechanical quantities in order that his knowledge of mechanics may be real, and if any one question the necessity of including a discussion of simple physical measurements in a treatise on elementary mechanics, let him consider whether his lack of appreciation of actual measurement is not due to his having dwelt upon the abstractions of the subject for so long as to have lost to some extent the connection between theoretical mechanics and actual physical things.

2. As to the topic of wave motion and oscillatory motion, many, no doubt, will consider this to be beyond the range of elementary mechanics. Certain it is that

many of our best trained engineers know next to nothing of this topic. For example, one of the best engineers in the country upon asking a question a year or two ago with reference to the stresses produced in a system by impact was answered with absolute completeness insofar as the formal aspects of the problem were concerned, numerical considerations, only, remaining to be introduced; and yet he remained wholly unedified for the reason that the fundamental ideas of wave motion were entirely strange to him. The difficulty is that the theory of waves has been heretofore presented almost solely with reference to its use in the subjects of sound and light, and that the geometrical and mathematical theory of wave trains has entirely overshadowed the much simpler and distinctly physical theory of wave pulses. Very few even of our physicists have clear ideas of the wave pulse, and a person who does not understand the wave pulse cannot have any physical idea whatever of wave motion. It is high time that a study of the really simple physical theory of wave pulses be included in our elementary courses in mechanics and applied to the study of the very important subject of oscillatory motion.

Physical Arithmetic.—It would be strange indeed if the system of arithmetic which has been developed upon the basis of the counting of separate things, like coins and cattle should not be found wanting in some essential particulars when the attempt is made to extend it to data obtained by physical measurement. The idea of continuity, of continuous variation, is entirely foreign to "coin and cattle" arithmetic and it is doubtful if more than a very small fraction of

our students ever grasp the idea of continuous variation. The fundamental ideas of calculus can never be made intelligible except on the basis of physical measurement. We all know how completely abstracted from physical considerations the present methods of presenting calculus are, and nearly every teacher of the physical sciences feels that a great majority of our students fail utterly to profit by their painstaking study of calculus. In our teaching of advanced electricity, for example, we have every year for many years asked our junior class the question "When does a growing thing reach its greatest size?" and we have only once or twice drawn out from a member of the class any statement approximating to the only plain and simple answer, namely, "When it stops growing"; and yet every member of every class could perhaps have covered a whole blackboard in solving a properly labeled problem concerning the maximum or minimum of a specified algebraic function. What is the use of such stuff in the entire absence of ideas? When will our mathematical teachers stop their unlimited algebraic elaboration, which is by no means confined to calculus, but perhaps is most offensively exemplified in the teaching of the utterly useless higher algebra, and lend a helping hand in the really serious business of imparting ideas? Let it be understood that by ideas is meant here only those things which actually connect with physical and mechanical things. The real object of the technical part of technical education is to train a young man to deal with the physical conditions which mankind faces in this world of ours; and the physicist and chemist (including the

engineer) have gone so far in the devising of methods for doing this thing that it is a wonder that the useless elaborations of those who teach mathematics is tolerated for a moment when there is so much simple and effective instruction that might be given in elementary physics and chemistry, most of which is of a character to exercise the logical faculty quite as severely as our courses in advanced mathematics.

Our present undergraduate courses in mathematics may be criticized not only on the basis of the relative importance of pure and applied logic, but also with reference to the choice of subject-matter in the field of pure mathematics. For example, our undergraduate courses in mathematics entirely ignore the ideas of the vector and of the vector rate of change without which no one can get any clear idea of velocity and acceleration; and the whole mathematical machinery of modern electromagnetic theory is outside of existing courses in elementary mathematics, to say nothing of the fundamental ideas of kinematics; and yet all of these things are simple and the teaching of them is entirely feasible. Experience convinces us that the ideas of scalar and vector potential and of vector convergence and curl, without which the fundamental ideas of electricity and magnetism cannot be assimilated except in a very crude way, are easily within the reach of the average young man provided he be not previously spoiled by the wrong emphasis of present undergradute mathematical courses.

In regard to the subject of dimensions of physical quantities, which may be properly spoken of in connection with this matter of physical arithmetic, it

seems to us that this matter has been exaggerated beyond all reason in many modern treatises on elementary physics. The fact is that the dimensions of a physical quantity are entirely arbitrary and meaningless, and their only use is that they enable one to detect certain kinds of errors in algebraic transformations. Their use in enabling one to reduce from one system of units to another is of some importance, but nearly everybody makes such reductions without explicit reference to dimensional formulæ by considering the fundamental physical equations themselves.

Lecture and Recitation Work in Mechanics.—It is desirable to give simple experimental demonstrations in the lecture room and to give to the lectures themselves a distinctly theoretical character, the main object being to enable the student to see the application of abstract principles to concrete cases. In regard to recitation work, there seems to be a widespread tendency among teachers to do nothing but hear recitations by the students and grade them upon what they have been able to extract from the textbook. This sort of thing may be proper for mathematics, but it is absurd as a method of teaching physics. No student can get any physics of any kind out of any book that was ever written, any more than he can learn to be a machinist by reading a book, and therefore, instructors should devote a large portion of the recitation hour to showing simple pieces of apparatus, explaining problems, and illustrating the applications of ideas to actual things. Recitation work by the student should be reduced to the minimum amount that is sufficient to enable the instructor to judge of the

diligence of the student and of the progress that he makes.

Problem Work in Elementary Mechanics.—It is of the utmost importance that the problems used in the elementary course in mechanics be stated in terms of real conditions, reference being made in every case, if possible, to actual mechanical devices. A prominent use of such highly artificial concepts as frictionless pulleys and planes, ideally smooth pegs, inextensible cords with perfect flexibility and the like, in the manufacturing of problems, is, in our opinion, disastrous. Consider, for example, the problem of Atwood's machine as ordinarily given in courses in elementary mechanics, where, in order to make the problem simple, the cord and wheel are assumed to be without mass, and the system is supposed to be frictionless. How much better to refer to the familiar elevator where an object standing on the platform gains a certain amount of upward or downward velocity in a specified length of time. Every one has experienced the effects which are produced, and the fundamental relation between unbalanced force, mass, and acceleration is much better exemplified by this problem which refers to an actual device than by any number of problems referring to ideal Atwood machines.

The Tendency to Depend upon Algebraic Formulæ.—Mathematics is no doubt a tremendous labor-saving machine in its application to the physical sciences, and the practising engineer should use it as such, but it is as absurd to use labor-saving mathematics in the teaching of elementary physics as it would be to

teach blacksmithing by having an apprentice push a bar of iron into a nail-making machine! Any one who has taught elementary physics in a technical school knows how nearly impossible it is to persuade students to carry out a physical argument, they almost always begin the discussion of a physical problem by saying "We have the formula" and in nearly every case they "have" nothing else but the formula, and they cannot be made to assimilate anything else. A good example of what we mean by this, and an example which will illustrate what Professor Perry seems to have in mind when he speaks of a boy forgetting his formulæ and forgetting everything else at the same time and ever after having a dislike for mechanical theory, is as follows: An elevator car having a mass of 2,000 pounds gains full speed of 8 feet per second upwards in 2 seconds of time. What is the average tension in the suspending rope while starting upwards? The average rate of gain of velocity is 8 feet per second divided by 2 seconds, giving 4 feet per second per second. This acceleration multiplied by the mass of the car gives the unbalanced force in poundals which must be pulling upwards on the car. Dividing this unbalanced force in poundals by 32.2 gives the unbalanced force in pounds-weight, and the tension of the rope must exceed the downward pulling of the earth by an amount equal to this unbalanced force. Therefore the tension of the rope is 2,000 pounds-weight plus $1/32.2 \times 2{,}000 \times 4$ pounds-weight. Compare this with the following "explanation" taken from a student's paper: "We have the formula $T - mg = mf$, in which T equals the tension

of the rope; m, the mass of the car; g, the acceleration of gravity; and f, the acceleration of the car. Substituting the given values and solving for T, we have the answer.'' It would appear that it is time for old-fashioned mental arithmetic to be insisted upon in teaching elementary physics, and we have adopted the plan of requiring certain questions in quizzes and examinations to be answered on the condition that no two letters be written together except in actual words, and that no two numbers be placed in position for ordinary multiplication and division, thus making it necessary for the student to use mental analysis for the solution of the problem. No doubt this tendency for students to rely upon formulæ is largely due to the giving of problems in elementary mechanics (so-called) requiring elaborate mathematical treatment such as the problem of finding the position taken by an ideally smooth ended stick in a perfectly spherical bowl with frictionless sides.

Laboratory Work in Elementary Mechanics.—A student should work in the laboratory from the very beginning of his study of elementary mechanics in college. However, there are certain things which must be assimilated by the student through the power of his imagination, and many of the extremely simple qualitative mechanical experiments must be omitted from the laboratory course, such as the verification of the parallelogram of forces, the verification of the principle of moments, the use of Atwood's machine, and the like; and above all, we believe that it is time for teachers to recognize that laboratory work in mechanics means something besides experiments with

pendulums. A list of experiments in simple measurements and mechanics is given in the paper on "A Course in Physics," presented by Professor Franklin at this meeting.

The Laws of Motion.—It is time that teachers of elementary mechanics be made to understand that Newton's Laws of Motion apply to terrestrial things, and particularly that the first law of motion does not necessarily involve an idea of eternity! How absurd, for example, to give an example of the first law of motion by stating that if there were no forces acting upon a body then "the body would go on forever in a straight line with uniform velocity"; when, as a matter of fact, every train of cars which moves even for a fraction of a second with uniform velocity in a straight line exemplifies the first law of motion! The attempt to illustrate the laws of motion by highly ideal cases is more than anything else responsible for the failure of students to realize the application of these laws to ordinary mechanical phenomena; and to say, in respect to the first law of motion, that "we never see this law practically exemplified in nature because it is impossible ever to get rid of all forces during the motion of a body" is idiotic. There is certainly a widespread notion in academic circles that the laws of motion apply only to the movements of the planets of the solar system, and there exists a pitiful ignorance in these same circles of the applications of the principles of mechanics to such things as machinery, and trains, and boats.

Mass and Weight.—We are very much surprised to find from the discussion of elementary mechanics

before the Johannesburg Meeting of the British Association, that a number of the participants, especially Professor John Perry, favor the adoption of the "slug" (32.2 pounds) as the unit of material, and we are even more surprised to find a slighting reference to the chemist as the chief offender in the perversion of the word pound from what is insisted upon as its proper meaning as a unit of force! We would like to know by what measure English people have been buying sugar and wheat and selling iron and coal for the last hundred years. We doubt if any shop-keeper in England would understand Professor Perry if he were to ask for a slug of meat or bread. The fact is that our engineers have been so completely absorbed in their use of the pound-weight for measuring strengths of materials that they have forgotten the use of the pound for measuring what they eat. If it comes to a question of usage by a majority of people, the pound must stand as a unit of material, and it seems to us to be utterly absurd to propose an unused unit like the slug to take the place of the pound (of coal or iron) in an attempt to "simplify" the equations of dynamics. On the other hand we are convinced that the gravitational unit of force, the pound-weight, will continue to be used as the unit of force, everywhere among engineers, or, when we adopt the metric system, the kilogram-weight. There is no doubt that practical units should be accepted in their entirety, pounds of cargo and pounds-weight of propelling force. It is necessary, however, to use the word slug or the word poundal so as to enable systematic units and practical units to be connected in

intelligible argument, and we prefer the word poundal for this purpose.

Notation.—It is greatly to be desired that writers on mechanics and on the branches of technology which are based upon mechanics should adopt a uniform system of notation. This has been done to a great extent among writers on elementary and applied electricity, and it is a very great help to the student. If we are to have a uniform system of notation it will be necessary to consult both the engineer and the physicist, and we suggest that a committee be appointed by this Society to consider the question of notation for elementary and applied mechanics. It seems to us that this Society can consider this matter more effectively than any of our national engineering societies, inasmuch as the notation of mechanics affects every branch of engineering, and no one of our national engineering societies would be able to establish a uniform system of notation in mechanics such as has been to a very great extent established by the American Institute of Electrical Engineers for theoretical and applied electricity.

At the Johannesburg Meeting of the British Association Professor Perry had something of interest to say, but the remainder of the discussion of this subject was very largely an endless repetition of platitudes. The difficulty seems to be that teachers as a rule have no idea at all of the psychological problems of teaching or any clear-cut philosophy of their profession, and the result is that their discussion lengthens out into a dismal catalogue of minute detail of how they do this or that particular bit of class-room work.

Joint Discussion.

Professor Merriman: Referring to the problem where the tension in the rope of an upward moving elevator is required, I note that the solution given is well calculated to embarrass and mystify the student, on account of the use of poundals and the entire neglect of the physical aspect of the question. The physical fact or law which the student ought to have in mind is that the accelerations produced or overcome by similar forces acting on the same body are proportional to the intensities of those forces. Here the given accelerations are 32.2 for the 2000 pounds weight and $32.2 + 4.0$ or 36.2 for the tension in the rope, both in feet per second. Hence the ratio of the tension in the rope to 2000 pounds weight equals the ratio of 36.2 to 32.2 which is 1.124, and accordingly that tension is 2000×1.124 or 2248 pounds weight. Reasonings of this kind ought to be employed in elementary mechanics, and I know of no necessity or advantage in the use of poundals. Physical laboratories have no apparatus for measuring poundals, and in my opinion it is not advisable to introduce beginning students to fictitious units of measurement.

Professor Cooley: We have been trying to discuss the papers in relation to the duties of a dean. Now we have reached the point where the duties of a dean may very properly be discussed. The conditions outlined in the papers relative to the dean struck me as being too largely ideal. They correspond with the solution of a problem which treats a body moving without friction. I may say from my own experience

that such a condition is entirely foreign to the real duties of a dean. Practically he is not the master of the situation, he is more nearly the servant, and often between the upper and the nether mill-stone, not only as relates to the student but also as relates to the faculty. It unfortunately is a position involving much drudgery, which in my judgment ought to fall to others. The real duties of a dean should be those of administration, the selection of teachers, the development of policies, and the co-ordination of work. He should control the numerous forces that a definite result may be obtained. This particular question now under consideration I conceive to be of great importance. It has to deal with the re-organization of work in engineering colleges, and it is one which is particularly pertinent to the situation in Michigan at the present time. We are considering the question of physics as it relates to engineering, and also of mathematics and of mechanics; they are live questions with us just now. These subjects are under consideration by our Standing Committee, which is made up of the heads of our different branches of instruction. There is a belief that the subject of physics is not taught so as to be of the most value to the engineering student. I mention this as I hope it will receive a very active discussion. I think a great deal of time is frequently lost in our engineering courses because these subjects are not presented so as to do the most good, or so as to accomplish the desired results with the least expenditure of time.

It is natural that the teacher should desire to en-

large on those things which interest him most; and the best that is in the teacher is often thus disclosed. But in an engineering course, sacrifices must be made, this natural desire must be curbed, to the extent at least that the student may have all parts of his work balanced up, each part bearing some definite relation to the other parts. To bring this about is, I conceive, one of the real duties of the dean.

DEAN KENT: I don't think the office of dean is one of great drudgery. I called on Dean Cooley before he was a dean, and he was not nearly as good looking nor as fat as he is now. He actually complained because he was not a dean; now he is complaining because he is one. One good model for a dean is never to do a thing yourself that you can get some one else to do for you better.

I approve of the statement of the authors that physics is the study of actual physical things and not by any means a weakly speculative branch of philosophy. Also, that the three methods of study of elementary physics should be carried on together; —namely, 1st, building of the logical structure, 2d, training in the performance of ordered operations, and 3d, exercises in application.

The difficulties in the teaching of physics are not greater than the difficulties in the teaching of any other subject. The greatest difficulty in the college is to find the teacher who knows how to overcome these difficulties.

Probably some teachers deserve the criticism offered of their ways in teaching physics. If so, there has been a degeneration in the methods of teaching

in the past thirty years; I remember three teachers of physics that I had and each one of them was an inspiration to his class. If the old teachers are better than the modern ones, possibly one reason is that the older ones were not afflicted with so much literature on the subject of physics. Physics in the old days was physics and not speculative philosophy, and the old writers knew how to use language to express and not to conceal thought.

I cannot agree with the statement of the authors that no one can get "any clear idea of velocity or acceleration" without having the ideas of the vector and the vector rate of change. I think I got a very clear idea of velocity and acceleration when I was a student and I do not think I have ever lost it, but I have never had occasion to study vector analysis; and I know some very good electrical engineers, capable of doing good work in alternating-current design, who have never obtained any ideas of scalar and vector potentials and vector convergents and curl. I do not doubt that vector analysis is a very powerful mathematical engine in the hands of those who know how to use it, just as calculus is, but it must be remembered that some splendid work in applied mechanics has been done without even the calculus. Weisbach's great work in its early editions did not use the calculus.

When I read the phrase, "dimensions of physical quantities," I understood that the word "dimensions" meant length, breadth and thickness, until I got to the bottom of the page and found that the word referred to the so-called dimensions of an equation,

used in what are called dimensional formulæ. I agree with the authors in their statement that the use of dimensional formulæ has been exaggerated beyond all reason in many modern treatises.

I regret to learn that "there seems to be a widespread tendency among teachers to do nothing but hear recitations by the students and grade them upon what they have been able to extract from the textbook." If this is true, it is another proof of degeneracy in the art and practice of teaching.

No doubt there is a tendency to depend upon algebraic formulæ, but it is an easy matter for the teacher to discover it and to counteract it. Every student of mechanics ought to be taught how to use the formula, how to get along without it when it is not at hand, and how when using the formula to be able to state its derivation. There are some formulæ, however, that it is well to memorize or else always to have at hand in a ready book of reference, of which it is not necessary always to keep in mind the logical basis upon which they were derived. For example, the formula for the area of a circle, πr^2; and for centrifugal force, WV^2/gR, I doubt if one engineer in a hundred could prove the truth of this latter formula one year after he graduates from college, or solve a problem involving centrifugal force without the use of this or some other formula.

I am not quite sure that the authors intend the solution given of the problem of the elevator car to be the solution that they would ask from a student. If so, I must take exception to their method. In the first place their method does not get rid of

formulæ. It merely states the idea which a formula conveys but in different language. "The average rate of gain in velocity is eight feet per second divided by two seconds." What is this but another way of expressing, $a=v/t=8/2=4$?

"This acceleration multiplied by the mass of the car gives the unbalanced force in poundals, which must be pulling upwards on the car." What is this but another way of stating $f=ma$? The problem and the solution as stated by the authors, however, are very objectionable in using language that is not used by the engineer. The expression "car having a mass of 2,000 pounds" would read much better to the ordinary man if it read, "car weighing 2,000 pounds." The use of the term "poundal," is one of the things in my opinion that has increased the difficulty of studying mechanics. As the authors have approvingly quoted Professor Perry on some matters, I will quote him on this matter of the poundal, from page 26 of his "Calculus for Engineers."

"One might as well talk Choctaw in the shops as speak about what some people call the English system, as if a system can be English which speaks of so many poundals of force and so many foot-poundals of work. And yet these same philosophers are astonished that practical engineers should have a contempt for book-theory. I venture to say that there is not one practical engineer in this country who thinks in poundals, although all the books have used these units for thirty years."

I also object to the expression "pounds-weight" as a measure of tension. A pound weight is a piece

of metal which the grocer uses in weighing tea. A pound is a measure of quantity of matter. It is also used as a unit of force; and no confusion whatever results from using the same word in the two senses. The context always shows which is the meaning intended.

My statement of the problem would be the following: The average acceleration is the quotient of the increase of velocity in a given time divided by the time. $8/2 = 4$. The force producing acceleration = mass $\times$ acceleration. Mass = weight/32. $2000/32 \times 4 = 250$. Add the dead weight, 2000 pounds, gives 2250 pounds.

A shorter method is by formulæ,

$$f = ma,$$

$$m = w/g,$$

$$\text{Tension} = f + \text{weight of car.}$$

$$(2000/32.2) \times 4 + 2000 = 2248.$$

If a student should offer this solution, he should be cross-questioned to see if he knew what the formula meant and whether he had a good reason for applying it to the particular example.

I had occasion some years ago to assist a student who was floundering in elementary dynamics and getting all mixed up in his ideas of mass, poundals, pound-weights, acceleration, and so on and he was totally unable to apply the logic of the book, with the professor's attempted explanation of it, to the solving of the problems given in the book. I gave

him a short drill to prove the fundamental equations of dynamics,

$$wh = fs = rs = \tfrac{1}{2}mv^2. \qquad (1)$$

$$ft = mv. \qquad (2)$$

$$f = ma. \qquad (3)$$

Then I told him if he would forget all about poundals and remember that m always equals w/g, and that w nearly always meant the quantity of matter in a body in pounds, although sometimes it might mean a tension in a rope or the force with which the earth attracted a body, and if he would memorize these formulæ and be able at any time to show how they might be derived from experiments on falling bodies, he would get rid of all his difficulties. After this drill he had no trouble with these three formulæ and could solve practically any formula in the book.

I object to stating that the gravitation unit of force is the pound-weight. Let us use the English language and say that the English unit of force is the pound. The unit of weight, that is, quantity of matter, is also the pound. It is not necessary to use either the word "slug" or the word "poundal." The English system is just as systematic as the C.G.S. system. If it is ever necessary to define force in terms of length, quantity of matter and time, then we can say that the unit of force is that force which if applied for one second to one pound of matter free to move will give it a velocity of 32.2 feet per second. The definition that the unit of force is a poundal, or that force which will give a one pound

mass a velocity of one foot per second in one second, is a definition which has never been used by any one on earth except the writers of recent books on mechanics and the unfortunate teachers and students who have used such books. The students have to forget these units as soon as they get into the junior class in the engineering college and begin to tackle actual engineering problems.

When I was teaching elementary steam engineering some years ago, I found that the first thing to be done was to get the students to forget all they had learned about poundals, "gee-pounds," pounds-weight, the gram-calorie, the centigrade thermometer, and the metric system generally.

PROFESSOR WILLISTON: I want to commend the statement made in the first part of Professor Franklin's paper that mechanics is very largely a matter of intuitive knowledge and that time should always be allowed for the students to absorb this intuitive knowledge before any attempt is made to teach them the analytical solution of problems in abstract mechanics. If students were given six months in a good mechanical laboratory before they were allowed to study the subject by lecture or recitations a great deal of difficulty would be avoided.

I must protest, however, at the author's use of the term "poundal" in teaching engineering students. The *pound* is the unit of force universally adopted wherever the English language is spoken, and to ask a student to believe that, when a one-pound weight is suspended from a tie rod, the force applied is anything but a pound, is an insult to his knowledge of

English and to his intelligence. This is responsible for endless confusion. Would that the word poundal could be omitted from all elementary textbooks on mechanics as it has been from the best textbooks on mechanics of engineering!

PROFESSOR MAURER: I used to be, as Professor Franklin apparently is, an intolerant in this matter of the "poundal" and "slug." I now believe that the methods and ideas represented by these terms are equally correct. I prefer the slug to the poundal method, but do not presume to criticise the use of the latter. In the British Association Report, already referred to, some widely-known teachers express entire satisfaction and report good success with the use of the poundal, and some equally well-known report the same with the slug. I think this fact shows that either method may be safely chosen.

PROFESSOR FRANKLIN: Provided you do not go as far as saying you weighed coal with it.

PROFESSOR MAURER: I find no necessity for weighing coal with the slug as suggested. As a "practical" (or impractical) unit, the slug is on a par with the poundal, or even the dyne.

PROFESSOR HAUPT: I wish to call attention to this fact that a clear distinction should be made between freight-tons carried on cars and those on water. There are five different kinds of units in use, so when the word "ton" is used there should be a limiting adjective to give it a definite value. For water purposes we have the net and gross register of 40, and 100 cubic feet (bulk), and for the French ton we have 2200 pounds, while for the overland freights there

are the long and short tons of 2240 and 2000 pounds. As a unit of measurement, therefore, the term ton is too ambiguous to be of much value.

PROFESSOR COOLEY: But in all cases the consumer pays the freight.

PROFESSOR A. N. TALBOT: I agree with Professor Maurer that both sides are right in certain respects; in other respects the contentions of both are wrong. We ought to agree that there may well be two systems of units for measuring mass, force and acceleration, depending upon the point of view of the user, and also that every unit should have a name. To make the relation "Force equals mass times acceleration" true requires a certain relation to hold between the fundamental units used. If the units of two of the factors be chosen arbitrarily, the third or derived unit must be so chosen as to make the ratio involved in the above equation unity. To the physicist, mass is the fundamental conception, and the determination of mass is made generally through a comparison with a standard body by means of a balance and the attraction of gravity, though possibly he may talk of it as obtained by ideal or theoretical means. He chooses the pound as the unit of mass, and as a consequence the unit of force must be the poundal. To him weight means mass and is a measure of commodity. The engineer starts with force as the fundamental conception. He deals with tension in a bar, pressure against the piston of a steam engine, load on a bridge or building, frictional resistance of a train of cars, power for running machinery, etc. To him weight means force, and even his workmen under-

stand that a weight of ten pounds puts ten pounds tension in the rope by which it is suspended, and that a pressure of ten pounds is similar to that involving the muscular effort of holding ten pounds against gravity. The engineer then naturally chooses the pound as the unit of force, and to him weight means force, not mass. The derived unit of mass to go with the pound of force must be the mass of a body which weighs g pounds. It is highly important to the student, in getting his conception of the relations, that a name be given to this, and either the g-pound or the slug may be used, though the former is preferable.

Both because in one method weight is considered to be mass and in the other force and because the effect of variation in the value of gravity acceleration may be confusing, it is well to aid the student's conception and discriminate between these two uses by presenting to his mind two devices for weighing—the beam balance and the spring balance. The physicist's conception is typified by the beam balance; he uses weight as mass, commodity; and this weight does not change with position on the earth's surface, though the force acting upon it does. The engineer's conception is typified by the spring balance; he uses weight as force and the force of the attraction on the body weighed will vary with the location and (considering the spring not affected by physical changes) the spring balance will measure this force even at the sun's surface, and if the local value of g be known, the fundamental equation will always give the same value of the mass of the body in g-pounds. It does not matter that we usually use the beam balance in

practical work (though sometimes the spring balance is used, as in the indicator), for the degree of accuracy of the engineer's work does not generally require modification for changing. It is important, however, that the student be given an understanding of the basis and meaning of the two systems of units. For either system there should be no confusion and no inconsistency. Each has its advantages, so let the physicist use his, and let the physicists be content to let the engineer continue to use his, for he surely will continue to use it.

DEAN KENT: I agree with Professor Maurer that there are two right things. But the engineer, and the commercial man, and the man in the street, and everybody uses the term "weight" to mean quantity of matter, and 32.2 is always the value of g. What I object to is that all the engineering students have to unlearn what they learned in the high school; that the elementary books on physics teach one thing, and we have to teach them another. The system that is most expedient is the one that the common people use; and the engineer uses the system of the common people. The physicists are a very small body of men, and I object that the books on elementary physics are written in a language which has to be unlearned later.

PRESIDENT HOWE: It seems to me mathematics is a science that has been developed by the mathematicians and we must teach it in a mathematical way. If we are going to teach mechanics, we must teach it as it has been developed by the men who have studied mechanics. But when an engineer comes to the practical application of mathematics and mechanics, it

takes but a few minutes to explain the difference between the theoretical work which the student has done and the practical applications he will make. To illustrate, a professor of engineering a number of years ago came to me and said that the students whom I had taught in calculus knew nothing at all of calculus, they could not understand his lectures. It all came from this point: I had used as a differential coefficient dy/dx; the professor used d_xy. I had given the latter as one of the forms, but had not used it regularly. A half minute's explanation by the professor would have made that point perfectly clear. You must place before the student the connection between mathematics and mechanics and then they can understand what is to follow.

PROFESSOR CHATBURN: I work up to these equations from Newton's laws of motion and have no trouble. I find that the teachers of trigonometry say the students are not taught algebra right; teachers of analytic geometry think trigonometry is not properly taught; teachers of calculus object to the teaching of analytics; and possibly the man who follows me does not like my method of teaching mechanics. We must always expect, temporarily at least, students to forget much of what they have previously been taught.

Here is a statement I should like to have the author elucidate a little more: "No student can get any physics of any kind out of any book that was ever written." It seems to me that is a pretty strong statement. No doubt the author himself frequently reads books, and while he may not get any physics out of them, his mind is acted upon in some such way that a

knowledge of physics is developed. I believe that a student who takes up physics in the elementary courses should have a textbook. I am strongly opposed to the teaching of elementary physics exclusively by the lecture and laboratory method. The student gets a few notes on a few loose sheets of paper and he thinks he has all the physics that is necessary. Later, when he refers to his notes, he is not sure that they are right, for experience teaches him that nine times out of ten he gets either a wrong impression of the lecturer's meaning or makes mistakes of omission or commission in taking his notes. But if he has even a small textbook or a book that merely gives the formulas that he is to use, he has something definite, and, in the long run, is better off.

Professor Emory: I agree with the last speaker about the textbook. Perhaps some of us will abandon our later conceptions of the duties of a professor as being able to serve as a sort of mental surgeon. The student must work with books as a workman works with tools. I arose to discuss Professor Franklin's paper. Do we not abandon and dispute the fundamental conception of the principles of calculus when we say we must have no theoretically ideal conditions. The author uses an actual machine for instilling elemental knowledge, and yet that machine has weight and mass. True the friction and inertia effects are disregarded in the simple experiments and all treated as differentials of another order. If we will but carry along a similar line of instruction in calculus on the idea of differentials together with our analysis of mechanics the ideal and the real will not seem so very divergent.

Professor F. C. Caldwell: I wish to speak in regard to the teaching of electricity and magnetism from the point of view of an instructor in electrical engineering. There are just two points I would like to have the student know thoroughly when he comes to me. One is Ohm's law and the other is the magnetic circuit. If he knew these I could forgive all other shortcomings.

Professor Benjamin: I do not see any necessity for this letter M in the formula. I think W/g is better. Another thing I wish to suggest to teachers of applied mechanics and engineering—I always assume that the men who come to me do not know anything about mechanics. I start with these same fundamental formulæ, and the students have no difficulty in forgetting what they have learned in their sophomore year.

Professor Miller: I never use the word "poundal." I agree with most of the other speakers, that these formulæ look well to me, except that I use

$$W = M/g.$$

Professor C. A. Adams, Jr.: Professor Franklin has emphasized one point upon which too much emphasis cannot be laid, namely, the giving to the student a physical conception of the subject in hand, and the enforcing of that aspect of the subject in his problems and in his examinations. It is very easy to get the student into the way of using formulæ to solve certain types of problems; but that is not education. What the student needs most of all is the power of analysis, the ability to use his own mind

and apply the principles which he has learned to the solution of new kinds of problems; and he cannot acquire this power by simply memorizing formulæ in the manner implied by Professor Kent. The speaker does not undervalue facility in handling problems except when that facility is purely mechanical and experience shows that of this there is great danger.

PROFESSOR FRANKLIN: There are two systems of terminology in mechanics which are used at present by two groups of teachers, and our students are greatly and unnecessarily confused thereby. Let us drop the word *poundal,* or the word *slug,* or both; but above all, let us come to an agreement.

DEAN WOODWARD: A great deal depends on clear ideas at the start. I have no difficulty making my students see the fundamental equations clearly and seeing their truth in their own experience. I would like to state how I start out. After the students have been studying statics, and when they understand that all the forces that act have no resultant; in other words, that they balance each other, they quickly get the idea of an unbalanced force. Then I begin with the unbalanced force. I say, "Suppose here is a lot of material acted upon by an unbalanced force." They can see it clearly. Then I say, "Let us measure that force in some familiar unit, and let us call the force F. F is the measure of the unbalanced force upon the lot of material. How much does the earth act upon that lot of material in the same units of force?" Every boy knows that a very convenient letter for representing how much the earth acts is the letter W. "Now unbalanced forces acting upon a lot

of material at different times produce proportional accelerations.'' Every boy knows that when you double an unbalanced force you double the acceleration, you double the result; therefore he appeals to himself for the first equation. ''F is to W, as the acceleration that F produces is to the acceleration that the earth produces when it attracts as an unbalanced force, and that is g. In other words, $F/W = a/g$. That is the equation we want.'' And that is the whole story of the action of an unbalanced force so long as it is constant.

You can solve that for F if you like, and you will get $F = Wa/g$. If you want to put one letter for that fraction W/g, call it M and give it any name you like. It is true in all units of force, time, and material. It is a true equation in all sets of units. I would not solve Professor Franklin's problem quite as he does. I should say to the boy: ''How many forces are there acting upon that elevator, supposing there is nothing acting upon the sides?'' He thinks a minute. ''There are two—there is the pull of the earth down, and there is the pull of the rope up.'' ''Do they balance?'' ''No.'' As the elevator moves up, the pull of the rope must be the larger. Hence, the unbalanced force is $F - W$. The unbalanced force that acts upon that elevator is to the pull of the earth on that elevator as a is to g, where g is a quantity whose value must be determined by experiment. To solve for a, we have $(F-W)/W = a/g$, hence $a = Fg/W - g$.

Professor Brackett: The tendency of perhaps the majority of students is to work problems by rules, processes, forms or formulæ in a way that dispenses

as much as is possible with all thinking and all reasoning. The "nickel-in-the-slot" machine illustrates the method. Select a slot. Drop in the nickel. Turn the crank to the right, and examine what comes out. If it is not the thing sought, repeat the process, using a different slot. Probably the familiar formulæ of mechanics take the place of the slot machine most frequently, but any too carefully worded process may prove just as bad. The solution of a typical example in any one part of the subject may be used as a general form into which other examples are put with a few minor changes in words and values, while very little thought is given to the logical connection of the various statements used. Variety in the methods of presentation and variety in the students' own explanations have advantages and are often necessary. If there is any such thing as individuality among students, then some students will see things better when presented one way and other students will see the same thing more clearly when taught by a different method.

It is quite possible that most members of the class mentioned by Dean Kent learned the things taught them more readily than they would have learned what he taught to the balance of the class. And even if there were no other advantages in the use of mixed methods, it would certainly tend to destroy the dependence upon fixed and unintelligible forms.

Very similar reasons may be given for at least some use of different systems of units. A student certainly knows little of the subject when he cannot change a force expressed in pounds to its equivalent expressed

in poundals, or a mass expressed in pounds to its equivalent in "engineering units of mass."

Any measurement or any result is only half expressed when its numerical part alone is written, and surely nothing is better to impress this fact upon the student than the use of mixed units.

PROFESSOR FRANKLIN (written closure): The continued reiteration on the part of many of our teachers of mechanics to the effect, substantially, that the law of acceleration is the whole of mechanics is to me increasingly tiresome; and the focusing of our attention by Professor Merriman and others in this discussion upon the law of acceleration seems to me to indicate that, in their opinion, we younger men do not clearly understand Newton's Laws of Motion. I think that we can afford to ignore all discussion which is based on so narrow a view as being wholly beside the mark. The subject of mechanics involves a great many elaborations and ideas which are by no means self-evident to a person who understands Newton's Laws of Motion.

The fundamental ideas of elementary mechanics must be sufficiently generalized in form to permit of their application to the wide range of phenomena of heat, electricity and magnetism, and light and sound. I think that our teachers of physics are confronted with a difficulty which is but little appreciated by those teachers of elementary mechanics who are concerned with the application of the ideas of force, mass, acceleration, and energy to purely mechanical problems. My own experience is that the greatest difficulty in applying the fundamental mechanical

ideas to the discussion of the phenomena of heat, electricity and magnetism, and light and sound, arises from these ideas not being sufficiently abstracted from particular considerations, such as gravity. I find, for example, that the student who defines the foot-pound as the work required to raise a pound one foot high is apt never to realize that work can be done in dragging things along horizontally!

I think that the physicist, having to apply the ideas of mechanics to a wider range of phenomena than those familiar to any specialized engineer, must be allowed to determine the extent to which the fundamental ideas of mechanics are to be abstracted and generalized.

I freely admit that the physicists have gone too far in the development of what we call systematic units, and I think that our engineering writers are also guilty in this respect, in that they insist on the elimination of the proportionality factor in the equation expressing the relationship between force, mass, and acceleration by the employment of a unit which reduces the proportionality factor to unity. Instead of being content with the formula $F = ma/32.2$, where F is a force in pounds, m is pounds of material, and a is an acceleration in feet per second per second, nearly every one has an idea that a great gain in simplicity is accomplished by adopting, either a unit of force or a unit of mass which will result in the reduction of the proportionality factor to unity. For my part, I do not see why we should be so anxious to get rid of proportionality factors in the fundamental equations of physics. Very certainly, it would

be simpler to have more proportionality factors and fewer systems of units.

In regard to the use of the pound as a unit of material, I insist that it is so used by 99.99 per cent. of English-speaking people. A certain group of engineering writers are the only ones who insist on expressing quantities of material in terms of what some of them call the "gee-pound" or "slug." To my mind, it is ridiculous, in discussing the problem of acceleration of a steamship, for example, to reduce the amount of cargo from pounds to "slugs" before attempting to formulate the problem, and I think it is no less absurd to reduce the propelling force from pounds-weight to "poundals" before attempting to formulate the problem. The fact of the matter is, in my opinion, that the group of engineering writers who insist on using the "gee-pound" or "slug" have conceived the false idea that their position is a "practical" one and that the position they object to is a "theoretical" one, and, therefore, they refuse to listen to common sense in this matter.

The main point I wish to make in this matter is that it is a question not of principles but of simplicity and convenience, and that it especially concerns our students who at present are led to believe that some essential difference exists between the physicists and the electrical engineers on one hand and the civil engineers on the other hand, with the mechanical engineers occupying a neutral position. I believe very strongly that teachers of science and engineering should come together in the matter of definitions and units, and I believe very strongly that this never can

be accomplished by the dictation of a group of engineering writers who fancy themselves to be entrenched by practical considerations as opposed to what they conceive to be purely the theoretical considerations which determine the point of view of the physicists.

In answer to Professor Chatburn's question as to what the authors mean by the statement that "no student can get any physics of any kind out of any book that was ever written," I may say that I heartily agree with Professor Chatburn in what he says of the necessity of a textbook in the study of physics in the technical school. What the authors mean by this statement is simply that a very large amount of contact with things in the lecture room, in the laboratory, and in the shop is a part of the instruction in physics without which nothing substantial can be accomplished, and we believe, furthermore, that some kind of suggestive treatment of everyday phenomena is necessary to bring the multitudinous homely experiences of the student into the field of his physics study.

ADDRESSES OF WELCOME AT THE DINNER.

CHARLES S. HOWE,
Toastmaster.

Mr. J. M. Henderson: I came to this city in the year 1864, and I think I am safe in saying that there were not more than a half dozen men here who added "engineer" to their names at that time within this county. The population of Cleveland was then about fifty thousand. I had the pleasure of knowing those engineers. They spent their time practically marking out lines. Now, measuring from that day to this, I desire you to feel as I do, that the distance through which we have come is enormously great, considering that we are to-day entertaining a body of men who represent the vast body of men who are engaged all over the United States in this profession which forty years ago was practically unknown. When I came here there was a Mr. Case—an old gentleman who had done some surveying himself. It was on account of impaired health that he had devoted himself to the business of land surveying. He had been employed by the representatives of the Connecticut Land Company in clearing up the titles to their remaining lands, and in marketing them. He became one of the wealthy men of Cleveland. He had two sons who grew to manhood, but the older of them died; and the younger—a man not very vigorous of organization—spent his life in pursuits that were to his tastes. He was a fine mathematician

and a man of considerable literary attainments—well educated. Shortly before his death, I read in the papers that it was the intention of Leonard Case to devote a large portion of his estate to the establishment of this institution which is your host this evening, and that he proposed to establish a school of applied science. Shortly afterward the Case School of Applied Science was established. I have been for some years connected with this institution as a trustee, and you know what that implies. It is a sort of honorary position. The president and the professors do the work, and now and then they call us trustees to the front and make us believe that we really have some hand in the management of the institution.

The life of a modern man is a remarkable thing. It is hard to realize that I should be here speaking to you gentlemen to-night in a city of five hundred thousand people, having come here and mingled with men who were here at the beginning of the city's life. So that for all practical purposes, assuming that a man who takes care of himself has fifty years of work in him, there has practically been done here the work of two generations of men, while, so far as men of your profession are concerned, there has practically been but one. You stand here representing the profession which in this city, and throughout the West generally, had hardly a representative fifty years ago except the man who was engaged in railroad construction or the man who was engaged in bridge work, or the man who was engaged in the surveying of land. So it is to me a pleasure to

meet you, gentlemen, made especially so by the fact that in going over these events I have been able to start from practically nothing to the present surroundings of technical education and to come up to welcome an assemblage such as this.

THE TOASTMASTER: An engineering college should have upon its Board of Trustees at least one engineer. The Case School of Applied Science has upon its board an engineer who has built the largest telescope in the world. I have great pleasure in introducing Mr. Worcester R. Warner.

MR. WARNER: It was a great pleasure to me this morning to attend part of your session, and you struck the keynote in a subject we have been studying for many years, and that is the question of leadership and the measurement of men. I think it is one of the most important elements in the education of a young man, especially in the technical college. You measure your students by their standing,—such a per cent. in this lesson in this class, such a per cent. in that, and finally he has a certain standing at the end of the year, or the course. Sometimes when he goes out into the world he does not stand up to his measure in college, while, on the other hand, some of the lowest grade will reach the highest eminence. The valedictorian of his class may never be heard of again. I will give more for the chances of the president of the class, than I will for the valedictorian.

VOICES: We all recognize that.

MR. WARNER: The one who is chosen by his peers to be their leader illustrates what Emerson meant

when he said that if a boat load of men were wrecked on a desert island, the first day one would lead all the rest, and inside of three days he would be their king. On the question of how to measure these men, I can't speak as a college man. I will tell you what the business men do. We are measuring men all the time, and we measure them on the percentage basis, too. We pick out men to fill certain positions and we consider ourselves very lucky if we get one to measure up to the efficiency that we expect of a steam engine, or a crane, or a water wheel, anywhere from sixty to eighty, and ninety per cent. I think some electric generators go up to ninety-five per cent. But you cannot often get men to come up to that standard. If I get a man that comes up around fifty per cent. I say he is worth trying. That is as high a standard as we expect on an average in hiring men for positions. If we get a man at sixty per cent., we consider him a jewel, and one at eighty is a gem. You can't pay him too much. This matter of sizing up men is extremely important, for, after all, each man must make his own place and his own record.

In a paper recently presented before an engineering society, Mr. Dickie, formerly of the Union Iron Works of California, an old ship builder, gave me a new idea about measuring men. He said "A man is like a ship supported by his own displacement. When launched into the world he finds no empty place ready to receive him. No one scoops out a hole in the water to receive the ship: when launched she must displace her weight of the element into which she plunges." We measure a ship by its displacement, that is, the

amount of water it puts out of the way in making room for itself. If a ship has twenty thousand tons displacement, that indicates the size of the ship. What is the displacement of each boy in the class? But I do not need to start down there. What is the displacement of the professors and the deans and the presidents? Every one shows in his face and bearing the measure of his displacement.

It is pleasant to find a really big fellow, who does not have to talk on his business or his hobby all the time. I went to New York awhile ago and in the same car with me there were six bankers. I was the only poor mechanic in the whole lot. What do you suppose those bankers talked about till the wee small hours? Nothing but money and stocks. It was a good subject, but there ought to have been a dozen topics on which those men should have been posted, so that they would not have to talk shop away from their business.

Now, I must not welcome you too much, so only one more point, and that is this: We hear much about the boy under your direction. "He is going through college"—so his father says. It is a very good thing for a boy to go through college, but it does not amount to much unless you can make the college go through the boy. Let us bear that in mind. We must crowd the college into the boy. Gentlemen, we extend to you the heartiest welcome to Cleveland, and to Case School of Applied Science.

THE RELATIONS OF THE ENGINEERING SCHOOLS TO POLYTECHNIC INDUSTRIAL EDUCATION.

BY DUGALD C. JACKSON,

Professor of Electrical Engineering, Massachusetts Institute of Technology.

The impulses which caused the settlers of New England to found schools and colleges simultaneously with clearing the land for their dwellings seem to have universally affected the pioneers of this country, and the establishment of schools has played a notable part in their policy. The hardy frontiersman has seldom blazed a trail which schools have not promptly followed.

This regard for school education is not singular with the American people but it has been singularly universal with them, and a comprehensive educational system has resulted which reaches even to the remote byways of the country. An educational system which meets the needs of the country, however, must be something more than a mere comprehensive school system in touch with the people. It must not only offer education in general, but it must also offer those special educations which are necessary for the fullest development of each branch of human endeavor and service. In satisfaction of this condition, the great variety of professional schools have been established,—divinity schools, law schools, medical schools, schools for the professional engineer,

and on the other hand, trades schools of various characters. In the latter respect, however, this nation has been at fault. Some trades schools have been established and maintained, and manual training has come to be highly regarded,—perhaps here and there too highly regarded in the high schools though insufficiently established in the grade schools; but the development of trades schools has been insufficient to the country's need, and foremen's schools are still almost unknown.

A wise enactment looking towards the establishment of these schools throughout the nation was passed by the National Congress during the period of the Civil War, whereby each state of the United States was allotted an acreage from the national public lands in proportion to its national representation, the proceeds to be applied more particularly to instruction in agriculture and the mechanic arts, without excluding other subjects of study. This wise enactment, born in the midst of civil strife, has been the foundation of many of the great state universities which make a notable feature of various of our western states. The United States Congress of recent years has added continuing appropriations of money for the same purposes, but more particularly with the design of supporting agricultural research.

These appropriations have been used with wisdom and with great advantage to the nation and its people; but, as far as mechanic arts are concerned, the term has been construed liberally and the work of the colleges using these appropriations has been largely in the grade of professional engineering work or

trending in that direction. The demand for university-trained engineers has been marvelous and the "land-grant" appropriations have been insufficient to support more than one educational effort in this line, and in many states they have been insufficient to support even one fully, so that it has been excusable in the past for the state colleges and universities to limit their activities. The diversion of fine private bequests from their apparently intended use for the foundation of trades and foremen's schools, to a support of attempted professional engineering schools, alongside of engineering schools already in existence, seems to me not so excusable.

In agriculture, the situation has been different. The individual farmer as a rule is unable to carry on extended and expensive experiments for the benefit of himself and his fellows, and the agricultural schools have turned their attention toward helping the individual farmers or dairymen by teaching them how best to carry on their trades. Some of our best schools of agriculture are what, in industrial lines, would be called foremen's schools, that is, they teach of the particular craft involved and the way in which the craftsmanship may be most advantageously invoked and applied by a master craftsman in everyday employment. These agricultural schools also support courses of instruction in scientific agriculture which are of university grade, and they maintain extensive and well-manned departments of research which have returned uncounted advantages for the appropriations expended.

The agricultural schools have thus undertaken to

cover a triple field: The field of the master craftsman, the field of the scientific or professional agriculturalist, and the field of agricultural research; and, in the main, they are occupying each of the fields well. This is in great contrast to the situation of industrial education, in which schools for master craftsmen,—*i. e.*, foremen's schools,—are so few as to be almost unknown.

The lead of the agricultural schools arises partially from a lack of farsighted altruism amongst the agricultural people, who clamor for the expenditure of public funds to advance agricultural education in all its branches, and especially those branches that come close home to the individual farmers and dairymen, but are selfishly unwilling to see public funds expended in those lines which appear immediately to aid the manufacturers, who, allege the farmers, are able to help themselves. This line of argument springs from the idea that the prosperity of the country rests upon its agricultural resources: and any one who has lived, as I have, for years amongst the people of the fertile plains of the Central West and Northwest cannot help but be convinced that this line of argument contains much of truth. However, it is false in its premises, because it fails to remember the unassailable fact that the prosperity of the agricultural interests and the concurrent contentment of the agricultural population are dependent in this country to an extended degree on the intelligence and prosperity of the industrial population. The interests of each,—the agricultural and industrial populations of this country,—are so bound

up together, that only by friendly co-operation in most things, including the educational interests, can the highest welfare of either be conserved. It seems to me that it is of almost as much interest to the mechanic or mill-foreman that the farmer shall be taught how best to perform his labor to bring forth the largest and best matured crops as it is to the farmer himself. And conversely, it seems to me that it is almost equally to the interest of the farmer and of the industrial foreman that the latter shall be afforded the best available training for the practice of his vocation.

Now, let us turn to consider the relative importance of proper education.

"Upon the subject of education, not presuming to dictate any plan or system respecting it, I can only say that I view it as the most important subject which we as a people can be engaged in."

What Abraham Lincoln thus said in 1832 is even more applicable to the conditions of our times. Only the education to be found in the elementary common schools was probably then in the mind of the speaker, and the extended school education, of a vocational nature, and especially of a professional nature, were apparently not within the purview of his experience; but these were not outside of his horizon, for he would have an extension of that education which leads to morality, sobriety, enterprise and industry, as is shown by another sentence from the same address:

"For my part, I desire to see the time when education—and by its means, morality, sobriety, enter-

prise, and industry—shall become much more general than at present, and should be gratified to have it in my power to contribute something to the advancement of any measure which might have a tendency to accelerate that happy period."

The happy period referred to in this quotation has manifestly made its appearance, but it is right to give sober thought as to the effectiveness of its coming and whether much is not yet to be done to accelerate the period. It is particularly appropriate for us, of this Society, to take this sober thought and give consideration to this matter on account of the close relations that engineering instruction ought to bear to the industrial affairs of the nation.

It is a question to be seriously considered whether the faculties of the engineering schools have yet duly recognized the responsibilities for the extension of the education through which comes "morality, sobriety, enterprise and industry," which rest on them because of their relations to industrial affairs. I believe that the agricultural schools, whatever their defects in altruism, have done better through more distinctly recognizing and assuming their part of such responsibilities.

The engineering schools, like their friendly rivals, the agricultural schools, have before them a field which may be divided into three parts—a triple field—two parts being semi-professional or completely professional and the third vocational, and subordinate to the others. The engineering schools have only occupied one effectively, though a few are now growing towards an occupation of the second.

These three parts to which I refer are the divisions of the educational scheme of the nation in which fall: (*a*) Engineering research and the advanced professional instruction which is being given here and there to a few graduate students; (*b*) The engineering courses of study as they are now ordinarily planned; (*c*) The instruction of artisans and especially instruction adequate to the needs of industrial foremen or sub-superintendents, that is, master craftsmen.

The second of these educational divisions in the order here named, it seems to me the engineering schools are occupying very well, but even here there is a lack of effectiveness which seems due to lack of correlation between the schools and lack of study of pedagogic history by those persons responsible for the direction of the schools. Reasonable independence and individuality in methods of teaching is due to the individual men who are experienced and worthy in each school, and the individuality of the several schools must not and cannot be infringed; but unhappily in the past, there have been contrasts of pedagogic views and professional ideals that cannot be justified, for in these things (matters of judgment though they be) truth can lie only in one direction, however diverse may be the paths over which she may be approached. In harmonizing these differences, pointing out the better paths to follow, and bringing the professional work of the several schools into correlation with professional practice, and especially in advancing the interests of engineering research and advanced professional studies which

go to the solution of those numerous great problems of engineering which can best be solved by men independent of commercial industrial control but working in full harmony with the best engineers and manufacturers of the day, this Society ought to have a large influence. I regret to feel that the Society has not heretofore maintained a large influence in these directions, but these matters will be brought before you for discussion in connection with a resolution which I propose to later introduce and in connection with certain proposed constitutional amendments that will come before you.

It is therefore not to these that I am here attempting to particularly direct your attention, but it is to the third educational subdivision that comes distinctly within the purview of the influence and direction of the engineering schools though preferably not within the scope of their curriculums. This is the instruction for artisans, and particularly the instruction intended for foremen and sub-superintendents.

The reports of the eleventh census give some illuminating figures in regard to the number of skilled workmen and the number of foremen in industrial pursuits. The figures must be admitted to be lacking in precision on account of the difficulty of drawing a line of demarcation between skilled and other workmen and the difficulty of phrasing an inclusive definition of the services that make a man of the rank of foreman, but the figures referred to are staggering in their indication of the magnitude of this problem in education.

As a farther indication pointing in the same direc-

tion, but belonging distinctly in secondary instead of higher education, I will call your attention to the fact that the first Industrial Commission of Massachusetts pointed out in its report of 1906 that there are no less than 25,000 boys and girls between fourteen and sixteen years of age in the State of Massachusetts who are now in various kinds of juvenile employments or are idle, and all of them without any adequate trade education. The secondary industrial schools of the country are utterly without adequacy in numbers or extent to meet this problem in secondary education; and schools suitably planned for the appropriate education and improvement of foremen are almost unknown with us.

I lay this latter fact at the door of the engineering schools, and hold that the members of the faculties are not guiltless unless they make adequate efforts to get filled this need in education for master craftsmanship in the industries, which comes within the purview of their influence and direction.

The governing boards of the engineering schools must divide the guilt with the faculties, if they continue their common failure to provide sufficient teaching force in the engineering departments, thus putting any effort which reaches beyond the routine of the department curriculum and touches the larger interests of the industrial body beyond the physical endurance of the individual members of the faculties.

The situation is better in our agricultural colleges.

Governing bodies have also been at fault heretofore by too close adherence to a standard for engineering teachers in which mere ability to impart

information in the class room, without consideration of any breadth of ambition, has held too predominant a place in the selection of men, and breadth of view in industrial affairs accompained by clearness of judgment has had too small a place. I do not undervalue the technical ability to impart information in the class room, and assent that this should be properly given much weight in selecting men for the engineering faculties; but this ability however largely developed and however fully accompanied by engineering skill is far from sufficient to make an efficient member of an engineering faculty.

The acts of many governing bodies heretofore are in some degree excusable in consideration of the breathless rate of growth of engineering schools which has seemed to make impracticable any pause for thought or consideration of needs beyond those of the day's pressing want of active teachers and suitable appliances to give strength to their teaching. It seems to me less excusable that so large a proportion of the leading men in the engineering schools should neglect on their own part a due consideration and study of pedagogic history and the development of the lines of philosophy and sound pedagogic thought, which lead inevitably to broader sympathies and more comprehensive professional views. An engineer who has cultivated a correct professional spirit ought to promptly recognize and fully appreciate the importance of careful study of professional precedents of the best types, and if the engineer is also a teacher, he seems to be under obligation to take a comprehensive view of both sides of his vocation, the side of engineering and the side of education.

I believe that such views lead emphatically to the proposition that engineering schools are called upon to extend their influence so that they will continue their present work of education for the scientific engineer; advance the work of engineering research and advanced professional study; and also foster the establishment, maintenance and development of polytechnic schools for master craftsmen.

As instances of a start in the direction of such polytechnic schools fostered by the faculties of engineering schools, I will point to the Summer School for Artisans at the University of Wisconsin, and the Lowell Institute School for Industrial Foremen at the Massachusetts Institute of Technology. Certain courses of the Pratt Institute are instances of work successfuly done in the same direction in an independent school, but even there the work is directed by men who have had experience in the faculties of engineering schools. Such schools supported by endowments or by the state could wisely be founded in each large industrial center, but in each instance the school government needs the combined interest, activity and support of the better manufacturers and of suitable members of the faculty of a great engineering school. It must always be borne in mind that these schools should equally assist the craftsmen and the industries employing them, and thereby improve the fitness and promote the prosperity of the state.

In the first part of this address I have pointed out that the contrast between the hitherto development of farm and dairy education and industrial foremen's

education is partially due to a certain trade selfishness of the farmers; but there are also two other active causes which are particularly strong in the eastern states. One of these is a hesitation on the part of associations of industrial workmen to give countenance to education which cultivates and strengthens the special aptitudes of each man and thus tends to accentuate and enlarge the differences between the abilities, usefulness and earning powers of individuals. This jealousy of education, notable on the part of some, is an unhappy phase of the development of civilization, but right-minded men soon find that appropriate and thorough education, for one's particular work not only adds to earning power and ease and satisfaction for the individual but it also reduces jealousies and tends toward a brotherhood which improves the condition of all workers. We are compelled by the inexorable facts of life to see that men are of different abilities, and nothing is gained by an attempt to deny or evade the truth. The best that we can do is to place each individual man, as far as may be, in the situation that he is best adapted to fill by ability and education. Then the advancement of any individual is a cause for the congratulation of all, for it makes new opportunities all along the line, for each individual to profit by in proportion to his demonstrated abilities, education and experience, and his readiness to work in co-operative relations with his fellows. For these and many other reasons which show that education is useful to all the men who are willing to profit by it, the organizations and associations of workmen

should not oppose but should favor the purposes of trades schools and foremen's schools. Happily, the more influential of such organizations are coming more and more to lend their favor to such schools.

This brings me to the second of the above mentioned contributing causes to the contrast between the condition of development of the agricultural and the industrial schools. Relatively few men have come to large fortunes through agricultural pursuits, but those whose fortunes have been so founded have ordinarily discharged their obligation by extending their personal favor and aid to agricultural education, and through endowments given for the same cause. Indeed, large numbers of men who have only won a fair competency through agricultural pursuits have given liberally of their time and even of money for the encouragement and support of agricultural education, and have seen to it that the expenditures have been made in the manner most useful to the people.

I am sorry to say that the men who have made fortunes through the manufacturing industries and transportation have seemingly not proportionally supported industrial education. Some large endowments and bequests have been worthily bestowed where the income is used in engineering education, and a few endowments are directed toward the support of trades schools, but all that has thus far been done is wholly inadequate and disproportionately small in comparison with the annual returns coming each year from the manufacturing and transportation industries.

The men who have come to wealth through association with these industries seem to prefer to found

great art galleries or museums rather than industrial schools. Galleries and museums have been proclaimed more widely, and their needs may have thus been brought more directly to the attention of those who have come to fortune through the industries and have money to bestow. In respect to that, while asserting that I will not take second place to any one in appreciation of the fine influences of art galleries and museums, I also insist that at the present juncture of education in this nation any man with a fortune to bestow can do a more pervading good by aiding the engineering schools to develop the work of engineering research, and by establishing schools for industrial foremen to be directed with the assistance and advice of the engineering schools.

Our communities maintain manual training schools and here and there a trades school, and great professional engineering schools are maintained in the East by private endowments and in the great states of the West by appropriations from the state governments; but there still remains a gap in industrial education which lies between the elementary trades schools and the professional engineering schools of university grade. This gap must be filled and it will be filled promptly if the men who are and who ought to be members of this Society do their duty. It is imperative to give to the thousands of young men who are to make the bulk of the corporals and sergeants of industry that education which makes for self-support in the best sense, makes for proper parentage, and makes for a good grade of thoughtful citizenship (to which foremen's schools may be

directed in keen fashion), before the education which lends figure and charm to a man's recreations (such as so fortunately comes from the art galleries and museums) is taken up. I believe that no use of money can bring greater returns to the state, or greater satisfaction to the giver who understands the educational situation, than large gifts for these purposes of industrial education that I name.

Discussion.

Dean Eddy: We in this Society have for a number of years had a Committee on Industrial Education, and there have been one or two of its reports printed in the Proceedings of this Society. One was written by our lamented friend, Dean Johnson, who was chairman of the committee at the time of the publication of that report. It attracted considerable attention throughout the country, and gave an impetus to fostering education in manual training, especially as connected with the industrial and trade interests of the community. But the newer and more interesting outlook of engineering education is that toward original investigation and research which has come as a sort of outgrowth of our engineering laboratory work. We have all experienced the feeling that our young engineers have, viz: anxiety to get into the work of life, and to be earning a living. They look to their profession as an immediate entrance upon responsibilities and opportunities of carrying forward the engineering work of the country, in building its railroads, in conducting its manufacturing plants, and generally in assisting to accomplish that which has

made this country so prosperous in the past few years. But now we trust a new feeling is entering the heart of the young man. Certainly, a new feeling is entering the hearts of the faculties of our technical universities and schools, and a new outlook. It is the feeling that the almighty dollar is not everything; but that the universe around us is to be converted to the uses of man in ways at the present time unknown, of which the past only gives faint glimpses; and although the results already attained have been so enormous and so startling, still the future holds greater things in its grasp for us to open up. These things—these secrets of nature—are to be unlocked by investigation and by experiment in order to make them useful to the human race. It has become impressed upon us that it is a new mind each time that makes a new step in progress, and usually it is a young mind which grasps the seed-thought which is to accomplish something great. There is given into our hands the opportunity to cultivate these young minds and give them impulse and guidance so that they may grasp the great principles of the future. We shall not perhaps do great things ourselves, but we shall have the pleasure of training those who are going to do them. And these great things cannot be done by just the short and meager work of a four years' course or an undergraduate course with the intention of immediate entrance upon commercial conditions, without a larger view of what education consists. I believe that the engineering faculties, as has been said by our president, are coming to a new realization of the opportunities and responsibilities of the present time.

Opportunity is, if possible, greater than responsibility. The forces and secrets of nature are never to be completely fathomed by the finite mind. But we continuously progress and our knowledge increases in a geometrical ratio. These are the things that enthuse us and make us ready to sacrifice for our profession, ready to do whatever we can for those who are coming after us.

Dean Woodward: I do not know that you all are as familiar as I am with the Mosely Commission—five hundred teachers of the secondary schools of England have been in this country during the past winter visiting our schools. A small percentage of them got as far west as St. Louis. It was noticeable that their chief interest centered along these industrial lines. They looked carefully and minutely into the housing and care of the poor, and the training we were giving them in an industrial direction. This interest seems to be growing all over the world. The President of the Board of Trustees of Case School referred to the astonishing growth of the engineering schools. These men are here because they are needed throughout the country. Our youth are going from the farms and from the shops demanding more education, and responding to that need. It is characteristic of the age. Young men are hungry for more training. They make a serious and earnest demand. There is nothing more characteristic of this than the fact that so many men come into our State universities who are reported as working their way through college. They come in without money and without parental support because they are determined to get an education, and

they are willing to work for it early and late, summer and winter. They carry two loads, only that they may get more education. This is what fills our engineering schools. There are not fewer men taking the classical courses or studying the fine arts, but there are more men going in our direction. The tremendous growth comes along the industrial and technical lines. We are reaching down, and as the president has said, we all have a duty to encourage and stimulate that interest, and promote their welfare by aiding these young men with our facilities, so that the lowest stratum in society may be lifted; because as we lift the lowest we shall also lift the highest. We do not believe that it is blasphemous to attempt to improve the face of the earth and the facilities for transportation. A couple of hundred years ago in Spain, two engineers proposed to an ecclesiastical council to improve the navigation of two rivers. They said, "If you will give us the opportunity and the liberty, we can improve the navigation of these rivers so they will be more serviceable." The ecclesiastical body thought it over and finally decided, that "if it had been the wish of the Almighty that these rivers should be navigable, He could have made them navigable without the help of human hands; as He did not do so, evidently He did not wish them to be navigable." So the improvement was forbidden. We believe that the earth is put into our hands ready to be finished. The unsolved problems are here for us to solve, and it is men like these we train that help to solve them.

Professor Williston: The President in his address this evening has been good enough to refer to the

work of Pratt Institute with which I am connected; and I wish to endorse his remarks, and emphasize them by saying that the demand for trained master mechanics, foremen and men for positions of similar grades is far greater, and the desire for such training on the part of those who are seeking it is more general and far more earnest than many of you can appreciate. It is nine years since I left the faculty of one of our engineering schools to take up this field of work in secondary technical education. At that time the department which I have had charge of had but a comparatively small number of students in its day courses, which were intended for the training of foremen, master mechanics and superintendents, in mechanical, electrical and chemical manufacturing plants. The first year that I was there, there were twenty-two graduates from these courses. This year there were one hundred and twenty graduates from the same courses. But this does not begin to measure the increase in demand that there has been for that work during this short period of time. If I could but give you the statistics of the number we could have trained and helped if we had the facilities to accommodate all who have applied, the figures would be most impressive. Our trustees have provided me with means to put up two new buildings, and we have twice doubled our accommodations. This is about as rapid a rate of growth as one can expect an institution dependent on private generosity to have. Yet next September I fear that I shall have to turn away from our doors, for the reason that we cannot find room for them, more than twice as many men as we

did last year. And the worst part of this is, there is no place where I can send them to get the training they have been saving up their money for. The rate of growth and the demand for efficient training in this field of secondary technical education during the last ten years has been more rapid than any similar growth that I am familiar with in the entire history of education.

As I have been describing this remarkable growth and demand for an education to fit men for positions of the master mechanic grade, some of you have perhaps been wondering how well we have succeeded in training this type of men, and in getting them, after they are graduated, placed in positions as foremen and superintendents in manufacturing plants. I have recently collected a few statistics from one of our courses which will answer that question. It will always require a considerable amount of actual experience in manufacturing plants, and a certain period of time, before the graduates of any school can show whether the training that they have received has fitted them for the kind of work which they wish eventually to do. Five years is about as short a period as one could safely assume in making such a test. So taking the full list of graduates of our mechanical course—which is the oldest course at Pratt Institute of the type described—and going back five years, that is, taking all of those who were graduated between the time when the first classes went out, 1896, and five years ago, 1902, I found that over *sixty-six* per cent. are holding positions of the type mentioned. They are either foremen, or master mechanics or superin-

tendents in charge of a construction department in some manufacturing plant. It seems to me that this answers the question. Doubtless many more of the thirty-four per cent. who have not yet found positions of this type will be promoted to them after a few years more of experience. It would be unreasonable to expect that in so short a period as five years more than two thirds of the graduates would have reached positions of responsibility. What engineering school could show that more than two-thirds of its graduates were in responsible charge of important engineering work within five years of their graduation?

I wish also to say a few words regarding the evening instruction for men employed during the day in mechanical or technical occupations. Parallel with the day classes that I have described, in every department of our work at Pratt Institute, we are carrying on evening classes for the benefit of those who cannot make the sacrifice of time and money that would be required were they to enter our day courses, and who wish some opportunity to get an education and training or increased technical skill, which will directly help them toward advancement to positions of greater importance or responsibility than they now hold. It is not possible, on account of the lack of time, to carry the training given in the evening classes as far as we do in the day courses, and the work is necessarily of a somewhat lower grade; yet it is surprising to see what can be accomplished in three nights a week during the six winter months of the year. And if statistics of the results were avail-

able, I believe that they would be almost as impressive as those which I have just quoted regarding our day classes.

The purpose is to have the instruction just as far as possible supplement the daily experience which the men are receiving in their regular employment. A part of it is given in our shops where the men have opportunity to get experience on a higher and more advanced class of work than they would be entrusted with by their employers, and also have opportunity to get a nicer appreciation of accuracy, a higher degree of skill and a power of reasoning which enables them to understand why a given job must be done in a particular way in order to get the best possible results. These men who have acquired new standards of workmanship and learned how to think in connection with their work and have caught something of the Institute's spirit which has stimulated their ambition have little difficulty, as I think you can readily appreciate, in outstripping their fellows in the race for promotion. But an even larger part of our evening work is given to men who are employed in mechanical pursuits in the day time, in our drawing rooms, laboratories or classrooms in such subjects as mechanical drawing, elementary machine design, mechanical movements and elementary kinematics, practical mathematics, elementary electricity, applied mechanics, applied electricity, electrical design, stationary engineering, strength of materials for mechanical and architectural draftsmen, industrial chemistry for those employed in chemical manufacturing plants, etc. If I remember rightly, there are about twenty-five different classes in all.

The growth of this evening work has been quite as remarkable as the growth of the day work. The year before I went to the Institute there were, I believe, eighteen students in our evening machine class. The next year there were thirty-six. The following year we had eighty-four applicants, but were not able to accept them all. A year later there were over one hundred and fifty, and the following year between two hundred and fifty and three hundred applications. Since then I have stopped counting, and do not allow men to file applications unless there is some possibility of our being able to accept them. The pain given to those ambitious fellows to whom we are obliged to say "There is no room" is too great. We have enlarged our facilities for this class twice, and are now able to accommodate one hundred and twenty men at one time in our machine shops, but as you will appreciate from what I have already said, this does not begin to meet the demand. I feel that I am safe in making the statement, without running the slightest risk of exaggeration, when I say that if I had the equipment and the corps of trained teachers in this one evening class alone, I could have in Brooklyn an enrolment next year of from six hundred to one thousand students. In other lines the increase in the demand has been very nearly as great. The sacrifice that these men are willing to make in order to obtain opportunity for study and advancement is almost beyond comprehension if one has not had a chance to observe them closely.

Our President has referred in his address to-night to the opportunities which exist for men of large

means for doing public service. But it would be hard indeed to find a place where they could do such lasting service or get such certain and generous returns for the money expended as they may in providing adequate opportunity for the elementary technical training of this ambitious type of men.

When I went to Pratt Institute nine years ago there were only a few over two hundred students in our evening classes. This year the number is very nearly a thousand, and in spite of the very large and increasing number that we are forced for lack of room to turn away. That, gentlemen, gives you some appreciation of the demand that exists on the part of the individuals who are seeking our assistance in their struggle for advancement, for whom our President has made his most eloquent appeal this evening.

Professor Franklin: A great namesake of mine once said that if you take care of the pennies the dollars will take care of themselves. I have been deeply impressed with the tremendous possibilities and tremendous necessities along the line of industrial training, as compared with the demand and possibilities along the lines suggested by President Atkinson's paper to-day. It seems to me that what is needed in this country, more than anything else, is provision for training in the trades. The engineering schools are meeting the demand for higher technical education. I have talked seriously with the men who control the Bethlehem Steel Company. They are anxious to establish night schools in connection with their very elaborate and very good system of apprenticeship; but they are at a loss to know where to go for sug-

gestions as to how that work should be done. The only thing that stands between them and the immediate realization of good school facilities for their apprentices is that sort of thing which this Society more than any other society could give them. I believe that the greatest educational institutions of this country in industrial lines and even in engineering lines are our manufacturing plants, and this Society should cooperate with the managers of our industrial plants in the establishment of schools for apprentices. It seems to me we ought seriously consider what we can do to help such men as the general manager and superintendent of the Bethlehem Steel Company.

Dean Goetze: I wish to add just a word to supplement what President Jackson has said about the great demand for instruction in industrial engineering. You have heard from Director Williston of the large numbers of applicants whom they are compelled to turn away for lack of facility, and in addition to these I understand that they had a waiting list last year at Cooper Institute, also located in New York City, of over two thousand names.

With a view toward bearing its share of the burden of helping these young men, who have to work all day and who are trying to help themselves, Columbia University, through its department of extension teaching, last November offered on very short notice a number of elementary courses in technical subjects, the instructors for the most part being drawn from the junior officers of our engineering school. In a few weeks we had a registration numbering over four hundred and fifty. More courses are to be added this year and there is every prospect of our having a much

larger registration in the fall. I know also from my own personal experience of the way these young men hunger for an opportunity to secure that knowledge which will enable them to advance themselves in the work in which they are engaged during the day, and I feel, with our President, that our universities and technical schools, especially those which are located in large cities, should do all in their power toward fostering this most important work.

Professor White: I looked up some statistics on engineering education in Germany. First I took all the engineering schools in Illinois and found that there was one student to every twenty-eight hundred people in Illinois; I took the same data for Germany, where they have twelve or thirteen first-class polytechnic schools, and found one student for every thirty-three hundred. But for the twelve or thirteen first-class polytechnic schools in Germany there are four hundred second-class technical and trade schools, and that accounts for the difference.

Professor Williston: Little Switzerland has been in the foreground in a great many movements and we are not surprised that she should be in the lead in the opportunities that she offers for technical education. In Zurich is to be found one of the very finest polytechnic schools in the world. I do not recall the number of students enrolled, but it is large.* Switzerland, with a population only about equal to that of Massachusetts, has, besides her fine polytechnic school, a number of excellent technical schools of secondary grade and something over three hundred and ninety trade and elementary trade schools.

* 1263 in 1903–4. See Procs., Vol. XIV, p. 256.

DEAN TURNEAURE: In Wisconsin, cities of a certain class have this year been authorized by the legislature to establish and maintain trade schools through the boards of education, the boards being empowered to levy taxes for that purpose. This legislation was passed at the request of people from Milwaukee who were interested in a private trade school there and who were members of the board of education. The expectation is that the board will take over this private school and levy a tax up to a maximum of $100,000 a year to maintain this school. Many who are interested in this project are of German birth, and familiar with the trade schools in Germany. Another movement along the line of secondary schools and trade schools is the establishment by the State of a school for mining workmen and mechanics at Platteville, Wis. It is called the Wisconsin Mining Trade School. The course of instruction will be of a secondary character and is to be to some extent under the direction of the College of Engineering of the State University.

MR. WARNER: I have been running a trade school for many years—for profit. The greatest difficulty we have is that too few young men, or old men, have learned how to think all alone. Your school and your college will be a success when you teach a boy so that he can think independently and alone, when you so train his mind that, when given a hint of an idea away off in the fog, he can get it and bring it out into the light. I expect soon to see Departments of Diplomacy and Tact established in all our best educational institutions. Such departments are needed in the

theological seminaries as well as in the engineering colleges and universities. In going past the George Washington University in Washington recently I noticed over the entrance of one of their new buildings "College of Diplomacy and Law." I want to see diplomacy and tact, which is another name for the same thing, given such emphasis that the graduates when they go out into the world can properly meet men and exercise leadership wherever it is needed.

PRESIDENT JACKSON: I am very much interested to know that Columbia University has begun to improve her opportunities. She can do a lot of good in New York, and she cannot hurt Cooper Institute. It will rise under Dean Goetze, I am sure. All these institutions will change, if they are run with tact and diplomacy. Lehigh University is at fault if it does not take up the Bethlehem Steel Company's problem. The one fault of the governing boards of our engineering schools is that they do not have large enough faculties. And these faculties are so burdened with work that they cannot give their time to these pressing requirements. What I wish to say in closing is this, that while my thesis this evening is on the importance of the foreman schools and the secondary industrial schools, I do not want you to think that I consider that more important than the advanced engineering instruction and research. I believe the latter is almost as important to the nation and to the welfare of its industrial development as the education of these foremen and workmen.

THE COOPERATIVE COURSE IN ENGINEERING AT THE UNIVERSITY OF CINCINNATI.

BY HERMAN SCHNEIDER,
Dean of the College of Engineering, Professor of Civil Engineering, University of Cincinnati.

About six years ago the writer began what might be called a pedagogic research into the problem of engineering education. After a time he sifted the problem down to three questions: (1) What requirements should the finished product of an engineering school fulfill? (2) Where and how shall we get the raw material to make the required finished product? (3) Through what processes shall we put the raw material in order to obtain the required finished product? This investigation has been carried on during these six years (and is still in progress) by visits to the largest manufacturing concerns in the Eastern and Middle States, in order to obtain from the employers of engineers their views on the subject. In a great many cases the men consulted were graduates of the best engineering institutions in the country.

About two years ago the results of the investigation, up to that time, were compiled and put into a formal paper which your speaker intended to present to this Society. He was reluctantly forced to certain conclusions by the inevitable logic of the facts gathered. But these conclusions were somewhat radical and revolutionary, and after a thorough consideration of the matter he had not the temerity to present the paper. It seemed to him that an actual demonstra-

tion of a system of education which was the natural outgrowth of this investigation would perhaps be the best proof of the correctness of the opinions of the men whom he had consulted. Opportunity was offered for this experiment at the University of Cincinnati, and the cooperative course in engineering now in operation is the result.

This course is so planned that the students taking it work alternate weeks in the engineering college of the university and at the manufacturing shops of the city. Each class is divided into two sections alternating with each other, so that when one class is at the university the other one is at the shops. In this way the shops are always fully manned, and thus the manufacturers suffer no loss and practically no inconvenience by the system. There are two facts on which it is desired to place especial emphasis so that there may be no misunderstanding about this work. First, the entrance requirements for this course are precisely the same as for the regular four-year course. Secondly, the university instruction under the cooperative plan is just as complete, thorough, broad and cultural as the four-year course. As a matter of fact, it is broader and more cultural. Let there be no misunderstanding about this. The course is not a short-cut to a salary.

The length of the course is six years. During this period the students work alternate weeks in the shops of the city throughout the scholastic year and full time in the summer. They are given one week's vacation at Christmas and two or three weeks during the summer. The practical work at the shops is as

carefully planned as the theoretical work at the university, and in all cases the students follow, as nearly as possible, the path of the machines manufactured, from the raw material to the finished product sold. For instance, at the Bullock Electric Company, the students spend the first year in the foundry, the next year and a half in the machine shop, the next two years in the graduate apprentice course, covering the commutator, controller, winding, erecting and testing departments, and the subsequent time in the draughting room and sales office. A contract is signed in triplicate by the student, the university and the firm. This contract has a blank space to be filled out with the shopwork the student is to receive during his six-year course. In all cases the dean of the engineering college and the professor of electrical, chemical or mechanical engineering, as the case may be, confer with the manufacturers in planning this course of shopwork, so that the young men get a logically and carefully planned shop and business training.

The students are paid for their services on a scale of wages beginning at ten cents an hour and increasing at the rate of one cent an hour about every six months. The rate at which the first class started was lower than this, but on account of the quality of work which the young men did in the shops, the manufacturers made a voluntary increase which is equivalent to about four hundred dollars for the whole course. The student's total earnings in the six years will amount to about two thousand dollars.

Young men desiring to enter this course are required to go to the shops in June or July preceding

their entrance to the university. We believe that certain men are mentally, physically and temperamentally adapted to engineering, and that the process of elimination which comes through this summer work weeds out the weaker ones and leaves us a residue which can be depended upon for results.

This course has been in operation for one year, and it will be interesting to you, perhaps, to observe how the elimination process works. Last year about sixty young men made application for entrance to the course. They were all sent to the shops to observe what the work was like and were asked to report back to the university office. Forty-five returned and began work; fifteen of these quit shortly after they began, leaving us a class of thirty last September (1906). Three of these men have been dismissed for poor scholarship.

This year we have had about four hundred inquiries and applications for admission to this course, by mail and in person. A great majority of these young men fade away when they learn of the conditions of the course. In the light of our former experience we are using a different method in acquainting the young men with the shop conditions, so that we shall have a smaller proportion of losses when we get them into the plants. Up to this writing fifty men have been placed in the shops for next year's class, and it is probable that by the time the class is filled we shall have between fifty and seventy-five student-apprentices.

It is interesting to note the reasons which prompted these young men not to apply for work, or if they

did apply, to quit work. Some of the reasons given were: "It looked too hard;" "I had to get up too early in the morning;" "The work was too greasy;" "I'd rather be a lawyer;" "I want to complete my education in four years instead of six;" "My father said they did not pay me enough;" "My mother was afraid I'd get killed;" "The boss spoke gruffly to me;" and so on. Some of the young men who withdrew from the cooperative course are in the four-year course.

A comparison of the work of the four-year freshmen with that of the six-year freshmen during the past year is worth a moment's consideration. The six-year cooperative students, although working but one half the time of the regular students, have done three quarters of the work of these regular students, including all the mathematics and sciences of the freshman year, and their average grades are twenty-five per cent. higher than those of the four-year freshmen. As a matter of fact, they have taken all the university work excepting three hours of English and three periods of shopwork, and of course, they have received much more shopwork at the city plants than they would have had at the university.

This course applies to the departments of electrical, chemical and mechanical engineering. It has not been found feasible to establish a cooperative course in civil engineering because the local conditions will not permit. The aim of the course is not to make a so-called pure engineer; it is frankly intended to make an engineer for commercial production. For the investigation spoken of in the forepart of this

paper disclosed the fact that a great majority of the engineering graduates are employed in commercial production, whereas the present college courses do not contemplate anything other than that the college graduate will become a so-called pure engineer.

I regret that the time limitations will not permit a further exposition of this course, for the experiences which we have had in one year's operation and in gathering our second class have taught us a great many things which I believe would be of interest to you. I should like, for instance, to point out in detail some of the following features: The advantage to the student of the extra two years of time for the assimilation of his theory; the effect of his shopwork on his theoretical work; the solution of the problem of proper exercise for the student; the knowledge he obtains of the labor problem, and of time as being the very essence of commercial production; the fact that this course resolves itself down to a training in commercial production with a university preparation in the underlying science—for you will note that of the six years, four are spent in practical shopwork, and that in the two years' actual time spent at the university the cooperative student gets more than the regular student does in four years. Your attention is called, in passing, to the fact that we are operating our engineering college at the highest efficiency, for, being given a certain sum of money to train a certain number of men, we are educating only those who by mental, physical, and temperamental adaptability are worthy of the expenditure made.

While there is no cloud on the horizon now, it is

possible that a combination of unfavorable circumstances may work harm to the course. But we have operated it long enough to know that under normal conditions it is a good thing.

In closing, permit me to say that it is believed this system of education will furnish to the manufacturer a man skilled both in theory and in practice, and free from the defects concerning which so much complaint is made. It is not held, of course, that this method of training will supply full-fledged engineers, aged twenty-three years, or thereabouts, but it is believed that it will provide a better preparation, a stronger foundation, for the successful practice of engineering. The qualifications which the engineering graduate should possess will be more nearly attained. He will be just as thoroughly grounded in the fundamental principles of science as he is under present conditions, but he will have greater facility in applying them to practical problems. He will be much more highly specialized, but not at the sacrifice of fundamentals. A knowledge of the achievements in other fields of engineering will result from his constant association with the best practice in electrical, mechanical, structural and chemical engineering, as exemplified in the construction of the cooperating works, in their methods of power generation and transmission, and in their processes of manufacture—his attention having been called to these details in the classroom, and his observation of them having been checked by searching questions thereon. He will become familiar with business methods by constant contact with business conditions, supplemented by classroom instruction

and practical talks on business law. He will obtain a knowledge of men by working intimately with all sorts and conditions of men in his gradual rise through the various departments of the cooperating plants. The cultural part of his education will be planned to make him a man of good address and broad sympathies.

And finally, a combination of these conditions will teach him to do his best naturally and as a matter of course. It will start him on his life work with a symmetrical and uniform fundamental development which will continue evenly and make him a skilled engineer, a safe business man, and a broadly tolerant and intelligent citizen.

(For discussion, see page 406.)

THE COOPERATIVE ENGINEERING COURSE AT THE UNIVERSITY OF CINCINNATI FROM THE MANUFACTURERS' STANDPOINT.

BY CHARLES S. GINGRICH,
Cincinnati Milling Machine Company.

There is a constantly increasing demand for properly trained technical men. Since our manufacturers are not prepared to produce such men themselves, they must look to the engineering colleges, technical and industrial schools to supply them.

Nearly all your graduates go direct from school into employment in some industrial establishment. They expect initial salaries commensurate with their education. In order that they may possess abilities that can command such salaries they should come to us with a training that will fit them for positions of at least minor responsibilities immediately upon graduation. At the present time most of them are diverted into the engineering departments, partly because of the attractiveness of the work, but *chiefly* because their school training gives them a greater initial earning capacity as draftsmen than they would have in other departments.

But we need well-educated engineers in the shops just as badly as in the drafting room. Unfortunately, your engineering courses as at present followed, do not give young men that practical training which is necessary to equip them for immediate usefulness in responsible shop positions, which can pay

high enough salaries to attract men of their years, education, and mode of living. About the only field that offers shop positions at all, is the electrical industry. These shops have certain departments, as for instance, the testing room, where they can use to good advantage young men with a school knowledge of engineering; yet they take your graduates only as apprentices for a two-year period and at an average wage which is about the same as that received by ordinary shop apprentices. They cannot do this well in the machine shop, and because these wages are certainly not tempting—the work is hard and dirty, and the hours are long—very few of your men go into the machine shops or foundries at all.

Now, these young men would make vastly better draftsmen, better designers, better engineers, better superintendents, and ultimately better managers, if they had a thorough shop training, and the shops would profit greatly if they could get these men, because we need a better class of men all along the line. It is evident, therefore, that there is a wide difference between the training which you give them, and the things they must know, before their abilities will be marketable to the shops at an attractive price.

At the present high tide of industrial prosperity, the need of technically and practically trained men is greater than ever before. Constantly increasing competition, not only between American manufacturers themselves, but competition with foreign manufacturers for control of foreign markets, will continue this condition for a long time to come. The manufacturers of my city have for some time past

been face to face with the very serious problem of getting the right kind of men. Our industries are diversified—including machine tool, steam pump, steam engine, and electrical shops. The machine tool industry predominates. We are rapidly becoming known as the chief machine tool manufacturing center of the country, but we need more technically trained men in the further development of this industry. It is our good fortune to have the University of Cincinnati centrally located among us. When it proposed to us Professor Schneider's plan of a cooperative engineering course, it appealed at once to the business sense of each individual manufacturer. The plan looked attractive from the business standpoint. It promised us an immediate supply of boys of a much higher grade than those who will take up the regular apprenticeship. It held out the prospect of our getting in a few years, engineering graduates with practical shop experience. We have all tried to give a shop training to young men from the colleges, but it never is entirely successful. A man who has put in four years of his young manhood getting a university education cannot get into the shop atmosphere even if he does don overalls and work at the bench or run a machine as a regular hand —such men have passed beyond the age and experience at which boys freely ask questions and learn quickly all those little details which are such an important part of the training and experience of shop men. They feel that they cannot afford to be laughed at. They do not want to expose their ignorance. Therefore they get at best only a superficial

knowledge of what is going on inside of the shop. I do not mean to imply that our shops are full of secrets, but I do want to emphasize the fact, that they contain a vast number of things to be learned, and the only place to learn them is in the shops, and the best way to do it is to start young and take plenty of time. The chief criticisms of modern technical education result from the fact that we try to take the shop into the school, whereas we should bring the school into the shop. The cooperative engineering course plan practically brings the school into the shop. Our present schedule of half time during the school year, and full time in the shop during school vacations, puts the boy in the shop eight months out of twelve; in other words, during the six years that he is taking the course, we have him in the shop four years—the same length of time that is served by our regularly indentured apprentices. The fact that these students are capable of taking the university course, is in itself proof of their high quality, and men of their class will grasp the principles as well as the details of shop work very much quicker than our regular apprentices. We expect, therefore, to give them a very broad shop training in the four years they will be with us. This will include experience in: (*a*) Machine shop, in several important branches, as lathe, planer, miller, vise work; (*b*) pattern shop; (*c*) foundry; (*d*) drawing room; in some cases perhaps also stock- and cost-keeping, and in still others, saleswork. While they are getting this, they will also be in close touch with the men and gain an intimate knowledge of the condition and atti-

tude of labor, which will be of value to them later as managers of men in the shops with which they will become associated. These boys will also learn the commercial value of time. Do any of our present engineering graduates know that? We are therefore giving these young men a thorough shop training while the university is giving them an engineering education at the same time. In this way we expect to make each of them into a fully rounded-out engineer—an engineer with an actual shop training obtained in a manufacturing establishment under regular shop conditions and on commercial work.

Now as to the direct value of it all: That man does not make the most efficient foreman or superintendent, who does not know all the "kinks" of the various trades under his supervision. He may be ever so efficient as an executive and have other necessary qualifications, but all these cannot fully compensate for the one thing which he lacks. The designer also must have more than a knowledge of kinematics and strength of materials. These will enable him to design a machine, but unless he applies additional practical shop knowledge, it will not be a commercially successful machine. There are in existence many beautifully worked out pieces of machinery, designed by highly educated men, which accomplish in a very satisfactory manner the object for which they were designed, but were never put on the market because they were so costly to manufacture that they could not compete with other similar machines of more practical design. Indeed, a great deal of the machinery that is in use will, upon close

examination, be found to contain parts which could be made very much cheaper, and in many cases better, if the designer had had a more intimate knowledge of machining, pattern-making, and foundry practice. A lack of thoroughness in the drawing room leads to tremendous expense in the shop, because it keeps on multiplying as long as the designs are in use. A designer should, therefore, be first of all a thoroughly trained shop man. These things will be required to even a greater degree of the chief engineer of the future. The general manager himself will be a far more efficient man if he has, in combination with his other abilities, a thorough knowledge of the things that the men under him are doing. This knowledge will aid him, not only to form a better judgment of matters for which he is responsible, but will also enable him to make correct decisions quicker, and thus economize his valuable time.

The cooperative engineering students will be given an opportunity to learn all these things. They will learn them in our shops under our direction. For our part we will have an opportunity to know the boys and form an exact knowledge of the abilities and possibilities of each individual. Some will no doubt develop into the right kind of men for the various shop departments; others, for the engineering department; and still others, for the sales department. But wherever we will use them, they will, each one of them, be a known quantity and ready for responsibilities.

There is another movement in this same direction which may be of interest here, as a further indication

of the efforts manufacturers are willing to make in order to develop the right sort of men. I have reference to apprentice schools. A number of these are now in successful operation. The best known and most successful is the one conducted by the General Electric Co. at Lynn. The New York Central Railroad Company is now establishing schools at all its shops. The Missouri Pacific Railroad Company has one in operation at its Sedalia, Mo., shops. While the methods of the various schools differ somewhat, the principle is the same. In each case the boys are under the direction of special instructors in all their shopwork and also spend a portion of their time each week, during shop hours and under pay, in the class room or at the drawing board.

The National Foundrymen's Association has provided the funds and equipment and is conducting a foundry school at the Winona Technical Institute at Indianapolis. The National Metal Trades Association is taking steps in the same direction for the establishment of a machinists' school. In Cincinnati, the Houston, Stanwood & Gamble Co. has for some time carried on a day school for class instruction with excellent results. The Cincinnati Milling Machine Co. has organized a night school—two hours a week for each boy. These latter are planned to teach the boys shop-arithmetic, drawing, algebra, and also a better use of English. The Cincinnati branch of the National Metal Trades Association is now considering plans for the establishment of a general apprentice school, to be shared in by the local manufacturers generally. It is proposed to conduct this

on the lines of the General Electric Company's school at Lynn. A separate, centrally located building will be fitted with machinery and our apprentices will work there instead of in the regular shops. They will turn out commercial work, keep regular shop hours, be paid regular apprentice wages, and work as nearly as possible under shop conditions. They will be under the direction and care of competent shop men, who also possess the ability to teach. The boys will devote a portion of their time to class instruction, the same as in other similar schools. Our case differs from the others in that a number of shops will have an interest in the school instead of its being under the direction of a single concern. We are confident of the same success that is being met with elsewhere. By this expenditure of effort and money we expect to make better and more intelligent workmen. Through the cooperative engineering course of the university we expect to have a hand in making better and more practical engineers.

The future promises, therefore, a better and more thoroughly trained class of men throughout our entire shop organizations.

JOINT DISCUSSION.

DEAN KENT: I happen to represent the Syracuse Chamber of Commerce on a Committee of Education. I consider this paper one of the most important I have heard at this convention, and shall give it a place in my report. I predict that you will meet the same disappointment that the agricultural schools have met with their efforts to train men for farming.

A large proportion of their graduates do not become farmers but teachers, so you will find in five years that your best men will be teaching school, and ten years later they will be attending our meetings for the promotion of engineering education. There is nothing more to be said on the subject. You have struck the right idea in education. Go ahead.

Professor Emory: To one who has followed this phase of education, it is a great pleasure to see the tendency of the times reflected in this paper. Twenty years ago the fundamental idea here brought out was laughed at by some of our more conservative institutions. The Worcester Polytechnic Institute was one of the first to make its instruction absolutely commercial. For many years their shops were self-supporting.

Professor D. C. Jackson: It seems to me that this scheme is substantially opposite to that of Worcester because it divorces the college from the shop. It puts the boy in the commercial shop and makes the college do the educational work, while the Worcester scheme was to make the college a great commercial affair.

Professor Jacoby: It will be interesting to know what these students did for recreation, and whether any of them were able to become managers of baseball teams.

Dean Schneider: President Dabney, of the University of Cincinnati, was good enough to put the operation of the whole plan in my hands absolutely, and the only rule regarding athletics I made was that no cooperative student should play on the varsity

football team. There is a certain pleasant rivalry between the regular four-year men and the cooperative students. The latter are organizing their football team now for next fall. We have a requirement that our regular four-year men shall attend two or three periods a week in the gymnasium, under the instruction of a director. We excused the cooperative men from this and as soon as they found out that they did not have a set period of gymnasium work, they presented a petition to the faculty asking for two hours of skilled gymnastics, such as fencing and boxing. Of course, we granted that.

PROFESSOR JACOBY: It is gratifying to learn that these two groups of students are in the campus games. That takes away the exaggerated attention upon the inter-collegiate games.

PROFESSOR FRANKLIN: I think we all realize the tendency of a college student to calculate and work up to the limit of allowable absences. To what extent are the men held to rigid attendance on shopwork, and what is the penalty, and under what conditions are they dismissed for negligence?

DEAN SCHNEIDER: A contract is signed of which one clause is, that if the student is dismissed from the shop, he is dismissed from the cooperative course. If he is absent from the shop, he loses that much wages. Any morning that the student happens to be absent from his shopwork, the superintendent notifies my office. We immediately try to ascertain the cause. The students did not seem to realize at first that it was necessary to send word to the shop if they intended to be absent, or if they were sick.

They are very careful about these details now. As to the university attendance, we have a rule that a student having ten per cent. of unexcused absences will be graded "Failed." The cooperative students did not seem to know that there was an absence rule. They felt that their business was right there in the classroom. The shop discipline has had a marked effect upon the character of the work that they have done in the university. The men are full of ginger and attend their classes with promptness and regularity. If all our students were like them, we would not need an absence rule.

DEAN RAYMOND: I would like to ask what the attitude of the unions is toward this matter, or whether the work is so carried on that the attitude makes no difference.

DEAN SCHNEIDER: All the machine shops with which we cooperate are open shops. Some of the foundries are closed foundries. There was a little objection at first. However, when the unions understood that this was not a scheme to make moulders, but a plan to train engineers, there was no further antagonism.

PROFESSOR WILLISTON: I assume that the men in the shops are subject to the same discipline as the other men. If they do not behave as they should and report as regularly, are they dismissed just as promptly as any other employees of the shop?

DEAN SCHNEIDER: Precisely.

PROFESSOR WILLISTON: How does the college regard these men, in those exceptional cases where some one does not do what is expected of him. Does the college treat these men in the same way shop people

would treat them, or are they treated in just the same way as the regular four-year students?

DEAN SCHNEIDER: There was a young man who did not like chemistry. He would not go regularly to chemistry, and would not do his experiments when he did go. He was dropped from the course.

PROFESSOR WILLISTON: You treated him the same way as you would any other student, but not the same way as the shop would treat an employee.

DEAN SCHNEIDER: We treat the cooperative students just as we treat the four-year students. We do not see any reason for drawing distinctions. But the men get so much discipline in the shops, we do not have any trouble with them. You will observe that when a cooperative student is at the university, he is subject to the university rules. When he is at the shop, he works under the shop rules.

PROFESSOR J. D. HOFFMAN: What is the minimum age limit for the men who enter the cooperative department?

DEAN SCHNEIDER: Sixteen years is the State law of Ohio.

PROFESSOR WILLISTON: Do they receive enough compensation to pay their living expenses plus the cost of their tuition and books, so that a student can be self-supporting? Or is it necessary for them to have some money saved before they enter?

DEAN SCHNEIDER: If the $2000 wages were distributed uniformly it would pay a student's way through. $3.60 a week is the lowest that it costs any student to live. His lowest shop earnings are $5.60 a week. We have a loan fund to help them through the earlier

years. Only two men last year applied for assistance. Working full time during the summer they can pay back to the university before graduation all that they borrow.

Mr. Wessling: There is one point in connection with what Mr. Warner said last evening which is applicable to these students and that is, "Take your chances on the man who is president of his class rather than on the one who has the highest marks." We have four of Professor Schneider's students at our place, one of whom is class-president, while another is class-secretary. I think that gives an idea of the standing of these men.

Professor Magruder: I will ask Dean Schneider what is the practice of the manufacturers in case they have no foundry and no pattern-shop? Suppose "A" goes to a machine-shop, where does he get his instruction in foundry work, molding and pattern work? Then I understand the work in machine drawing is done at the drawing rooms of the manufacturing department. Is that true?

Dean Schneider: The work in descriptive geometry is given at the university. The university course includes all descriptive geometry, statics, machine design, and so on. As to your first question, we have some men in shops that have no foundries. During the summer the manufacturer has two men's full time and during the winter he has them half time. So we arrange that during the summer one of these men will go to a foundry, and some other summer the other will get that work. In some shops they are able to give them the whole course straight through.

Professor Magruder: Do you give them the two years special apprenticeship course, and the four years in the university and the two years in the machine shop and foundry, all in the six years?

Dean Schneider: Yes; and also the sales office and designing department. Our school-year is eight months. Four months the student works in the shop and four months in the university. In the summer he works full time. That is four years of practical work he gets in solid time during the six years' course. He gets the equivalent also of a four years' college course.

Professor Magruder: Do I understand that two men, one being a six years' cooperative student, and the other spending four years taking the regular university four years' course followed by two years as a special apprentice, would at the end of six years be exactly in the same position in the race for life?

Dean Schneider: No; the six-year cooperative man would be ahead. We are arranging for the men to go into the drawing rooms and sales department. The man that goes through this work has been through all of the departments. He has a very broad view of all the methods of commercial production, and thoroughly understands the relation of his work to the work of all the rest of the shop. I want to say in connection with your first question that there is being built in Cincinnati, a manufacturing colony consisting of the Milling Machine Company, the Cincinnati Planer Company, the Warner Elevator Company, the Bickford Drill and Tool Company and the Triumph Electric Company. They will have a central

foundry and power plant. They are taking many of our men and you will see what wonderful opportunities are offered for them there.

PROFESSOR BRACKETT: May I ask whether no subjects from the four years' course are omitted in the collegiate part of this six years' course? And if not, whether the treatment of these subjects is not abbreviated?

DEAN SCHNEIDER: Nothing is omitted and nothing is abridged, and something is added. The course in chemistry this year was broader than the course given to the regular four-year men. The young fellows who enter the foundry get, during the latter part of the year, some shop-accounting work and time-keeping. In fact, after they have finished the hand-production work of every department, they get the cost-keeping or business end of that department. Along about the fifth year they will get a course by an expert, covering the various methods of cost-keeping and shop-accounting. Every other Friday night they are given a one-hour talk down in the city by some man who is an expert in his particular line of work. We will find one man who knows more about bevel gears, let us say, than any other man in the city. We will get him to talk to these students. These lectures are so arranged that while one man delivers one lecture, the sum total makes a complete course. Last year Mr. Wessling, of the Bullock Electric Company, gave a series of lectures on foundry practice. This work is not published as a part of the curriculum. When he gives the lectures to the next class he will have all the old class back; they will want to hear it

all over again, because they will be more interested.

DEAN KENT: I am not surprised that they get their work into six years. Because the authors state that they have a select lot of students.

PROFESSOR WILLISTON: Four years of college training plus six years apprenticeship in the shop plus two years as special apprentices makes a total of twelve. This is the equivalent of what is contained in the six-year course described in this paper; so the ratio is exactly two to one. This is proof of the statement that I have often made that you can *train* a man and *educate* him at the same time without either process interfering with the other. You can train him better, in fact, if you will educate him at the same time, and you can educate him better if you are also training him.

PRESIDENT HOWE: I am very much interested in the practical question of doing this. If the men are in the course six years and have four months recitation work each year, they will have altogether twenty-four months of work. For three years we give our students fifteen to eighteen hours recitation work per week. In order to do four years' work in three, we must either increase the amount of recitations per week by one third, or we must increase the length of the lessons one third. How is that problem to be met in this course?

DEAN SCHNEIDER: We increased the length of the lessons. In mathematics—that is a fair subject to take a test in—they have done more than twenty-five per cent. better work than the four-year men. The class is given an advance schedule of its lessons,

The whole year is scheduled in advance, every lesson, and the student knows what lessons he will have during his next week at the university. During the week at the shop he prepares some of his work.

PROFESSOR CALDWELL: In case an institution is not in shape to carry out the complete scheme as presented, would it be practicable, in Dean Schneider's opinion, to divide the work, giving a half of each day to each side and alternating the men forenoons and afternoons; this of course supposing that the factories are situated close enough to the college?

DEAN SCHNEIDER: No; the manufacturers would not accept a plan of that sort.

REPORT OF THE COMMITTEE ON INDUSTRIAL EDUCATION.

The purpose of this report is two-fold:

1. To advocate and make an earnest plea for the more general establishment of industrial schools giving strictly vocational instruction in both day and evening classes.

2. To report to the Society in a general way the progress in the movement for industrial education that the committee has observed since the date of its last report.

At the outset it should be stated that there are two kinds of industrial training, one whose chief and often sole purpose is to help young men to an immediate success in obtaining employment, and the other which aims also at the physical, intellectual and moral development of the boy.

The first kind of industrial training has flourished in many parts of Europe. A manufacturing establishment, a municipality, or a state government establishes an industry and then organizes a trade school to supply the operatives or "hands." It is evident that the training furnished by such a school must be simple, direct, and effective. It may produce a body of well trained and skilled workmen in a single line or between narrow limits; and may be exceedingly effective, looked at from the point of view of the business that it fosters, or from the standpoint of the young man anxious to obtain immediate and profitable employment. The results, however, while bearing

evidence of skillful hands in a few directions, as a rule, will have been secured at the expense of a broader training.

There are a few such schools in America and no one can object to their organization by industrial establishments or private means so long as they put no bar in the way of students getting a different kind of training in another kind of school. As illustrations of schools of this type we might cite the short courses given for the training of automobile chaffeurs offered by the automobile schools, or by the Educational Departments of the Young Men's Christian Associations, or by others; the short courses in plumbing, brick-laying, plastering and similar trades offered by such schools as Coyne Trade Schools of New York, Chicago, St. Louis and San Francisco, where the object is to give in the shortest time possible just enough instruction in the essential points of a trade to enable the applicant to secure employment; and similar courses of instruction in other schools maintained by private corporations to teach young men a limited number of operations in order to make them of immediate value to employers. There is a place for such schools and they may do a distinct good by affording an opportunity for young men to obtain kinds of employment from which they would otherwise be barred, but they cannot render the highest type of service.

There is, however, in this country another sort of trade school with a much higher aim which is altogether admirable. These schools offer longer courses and give a broader and more general training in the

trade or industry, and often include with the manual instruction such subjects as practical mathematics, mechanical drawing and those principles of elementary science which are essential to the full comprehension of all the operations that the trade involves. The purpose of such schools is to develop intelligence as well as mechanical skill, to cultivate ambition and high purpose, and to open for their pupils future opportunities for success and advancement as well as present opportunities for employment.

We need not discuss these higher occupation schools at length. They seem to deserve our hearty endorsement and every kind of encouragement. They give a knowledge of mechanical processes, a familiarity with many operations, a training in every grade of workmanship, and often an insight into a whole industry. Their work is on a high plane, and, like the engineering laboratories and shops of the engineering school, they put young men in possession of intelligence, skill and efficiency which will enable them to do their full share in the world's industrial progress.

In the preface of the Report of the first Moseley Commission which came to this country to study technical education, Mr. Moseley explains that he was induced to send a dozen of his countrymen to the United States in consequence of his observing in South Africa the careers of American engineers. He says in substance that he was amazed at what the Americans were able to do, and to himself he said, "I must investigate the institutions of the United States and see what influences have been brought to

bear to produce such level-headed men." This led to the sending of the Commission which praises so highly the American methods of technical training.

The European methods of industrial education which usually begin at the bottom are too limited in their scope. We wish to do no injustice to either English, French, or German institutions, but common observation is that there are few men who attend trade schools in those countries and become skillful workers in the simple manual arts of dyeing, or hat-making, or lock-making, or box-making, or knife-making, or paper-making, or weaving, who ever rise to important or responsible positions. Comparatively few ever seek or obtain higher technical training to give them the breadth of outlook on the industry in which they are employed that is needed before they can occupy a commanding place in it. Such results, where true, are unfortunate. Such training is narrow, and is never the best for citizenship nor for the young people concerned. Their lives are limited, shut in, and confined in a way that is obnoxious to the American mind. The American method is—or should be—to always point toward the top, no matter where the work may begin. Trade schools should aim to cultivate intelligence and ambition as well as skill, so that the recipients of their instruction, having learned the value of sound training, may always eagerly seek new opportunities to broaden their knowledge or to give themselves a deeper insight into their work. This is the spirit of our engineering schools, and this was what caused Mr. Mosely's Commission to praise them so highly. It is equally im-

portant, however, in the trade school, and it matters not how elementary the grade of technical or trade instruction, this spirit should always be present.

The introduction and development of manual training in the secondary schools of America was the first great step toward industrial education. It makes our industries as much the purpose of an education as are the higher professions, it trains our youth for service in industrial fields as fully and as reasonably as it does for service in other fields, and it makes the schools attractive and worth while to people whose vision is limited to the consideration of the ways in which one may earn a living and secure the means of maintaining a home. The manual training school, too, has proved to be one of the best means of properly preparing young men to enter engineering schools, and in the future a larger and larger proportion of those desiring an engineering education will probably seek this means of getting their preparatory training.

The practical question before us, therefore, is not the altering or meddling with our manual training schools, or manual art schools as they are sometimes called; on the contrary, we should encourage them and stimulate their growth. But we must also do something for that larger portion of our youth who never enter the secondary school at all, who fail more often than not to complete a grammar school course. These boys are not the "submerged tenth," as some-one has spoken of them—they are rather the submerged eighty-five per cent. of our youthful population, submerged that is so far as their education is

concerned. Either from lack of parental advice and influence, or because existing schools are distasteful to them, or from a real necessity, or from a strong desire to start early to earn their own living, the great majority of boys leave school too soon, and drift into miscellaneous occupations or no occupations whatever. Many of them grow up to be ignorant and unskilled workmen, and not a few to become thriftless, if not lawless, citizens. The most vital educational and social question of our time is what to do for this vast multitude of boys who now leave school so early. How may they be brought under the influence of a system which shall perform these two things; promote the public welfare by making of them valuable industrious workers, and promote their own personal welfare by helping them to improve their social position and to become better citizens. This is a question in which all members of this Society are vitally interested, whether we are teaching engineers or engaged in the education of those in a lower grade, because the greatest degree of success in any department of technical education can only come after we have learned how to make efficient subordinates of the vast army of the many thousands of boys who must every year enter industrial work, and yet, who never may stand on the threshold of an engineering school. Our responsibilities, therefore, to do what we can for them are certainly very heavy. We quote a paragraph from a recent paper by Mr. James P. Monroe:

"The next genuinely educational business before a community is to prepare the child for that industrial

usefulness, to himself and to the community, which is fundamental to good citizenship. He is virtually but half-educated so long as he has not acquired such necessary industrial qualifications as manual control and dexterity, cooperation of brain and hand, quickness of adaptation, fertility of resource, concentration, 'gumption,' and has not been given, on top of these, ample opportunity to secure the groundwork of some special trade or industry. Without such essentials, he is likely to join that appalling army of 'floaters' who, without a trade or any chance of learning one, wander from one casual occupation to another, depressing wages, inducing enormous industrial waste, and swelling at last the costly ranks of vagrancy."

The European methods of helping such young people would be vastly better than our present method of doing nothing for them, but what we have described as the European method is not practicable here for many reasons. We can, however, in the committee's judgment, organize modifications of it, that will work in America. If we cannot do the best thing, we should do the next best; if we cannot prevail upon those boys who reach the legal limit of attendance to remain longer and get the advantages of the secondary school we should offer them an opportunity especially provided for obtaining a sound vocational training. Vocational, or trade schools could be organized in which the greater part of the boys' time would be given to mechanical arts and trades instruction, carefully chosen with reference to the local industries in which the boys would be most

likely to find their future occupations; this work to be supplemented by such instruction in drawing, practical mathematics and simple principles of applied science as might be needed to make their comprehension of it broad and thorough.

The Massachusetts Commission on Industrial Training is recommending the establishment of such schools in all the manufacturing centers of that state which would receive graduates from the grammar schools, or pupils fourteen and fifteen years of age who have declared their intention of learning a trade, and which would always be kept closely in touch with the trades or industries by including on their local advisory boards representatives of the industries concerned, both employers and employes. Note that in advising the establishment of such schools as this, we do not recommend that any boy be compelled to attend this new industrial type. He should be absolutely at liberty to go to any school. Their doors should all be wide open with no compulsion toward any particular door, but there should be a compulsion toward some door. Our present compulsory laws of education stop at fourteen or at sixteen if no regular occupation has been secured, but this committee does not hesitate to advocate a continued attendance until fifteen or sixteen years have been reached, either in one kind of day school or another, or in evening school until an equivalent training has been received, wherever it is shown that home conditions make productive employment necessary at the age of fourteen. In offering to young people after they complete the grammar school the choice between the vocational

or trade school and the regular manual training school, or the classical high school, it should be admitted that the former, because of the short length of its courses, must be inferior to the others in the promotion of intellectual growth. Therefore every effort should be made to persuade the youth to choose the more thorough kind of training, or to obtain as much general education as possible before he begins his vocational work.

The immediate problem of industrial education also must deal with the thousands of young men already employed who are past the ordinary school age, and who could not, even if they so desired, give up their occupations and go back to school for such courses as have been described. These young men from seventeen and eighteen to twenty-five or perhaps thirty years of age for the most part have not yet received adequate training or education in any direction. They have had a portion of an apprenticeship, but nothing which has given them a mastery of a trade. What may best be done for them in industrial education is a problem which demands the most earnest and immediate attention, although it is one which will, perhaps, always exist. For such persons who must necessarily be at work during the day, evening or continuation schools are the only type feasible. It is evident that many of our school buildings with well-equipped drawing rooms and laboratories of applied science, and shops for instruction in manual arts, are very imperfectly utilized. They are occupied for a few hours each day for five days in the week. The rest of the time they stand idle and unoccupied.

They are capable of doing twice as much as they now do for education. Under proper management they could be utilized for the education of hundreds or thousands who neglected early opportunities, but who now, at a late date, desire to remedy their mistake to the best of their ability. Many manufacturing plants might also be able and willing to cooperate with those interested in industrial education and offer a portion of their equipment on certain evenings of the week for the same purpose.

For four years there was carried on at St. Louis with volunteer teachers a Sunday morning class for pupils who were at work during the week, and who were willing to spend the only free morning that they had in supplementing the imperfect education of their early years. It was a gratuitous affair, but it did a world of good, and many young men to-day attribute their advancement to what they received at that Sunday morning school. They studied mathematics, mechanics, drawing and English; and, although the school received considerable criticism from the pulpits in the city, those who started the school were glad to continue it, rejoicing at the advertising it thus received.

We cite this incident of the Sunday morning work in St. Louis in order to show the almost incalculable good that might come if only all our present facilities were utilized with the maximum efficiency, and to suggest to others similar opportunities to extend the use of their equipments.

But we cannot close this portion of the committee's report without calling the attention of the men of

wealth in the United States to the opportunity which is before them to set the pace in their respective communities by organizing and equipping new schools which may be used exclusively for vocational training, offering during the day trade courses of the kind we have recommended to boys fourteen, fifteen and sixteen years of age, and at night continuation courses for those already employed. Such schools would appeal to many boys who now drop out of the grammar grades and never enter the doors of a high school, and would attract many more whose tastes would be best satisfied by systematic courses of practical and tool instruction which would call into play both their minds and their physical strength, for in order to interest and inspire such boys their physical activities must be called into play, and they must see ahead of them something definite as the probable fruit of their effort; they desire the promise of a quick return. An industrial school with a definite outlook among useful occupations would attract and hold them.

The work of such a school in any large community would soon commend itself to the people of the city and to the Board of Education in such a way that it would be taken up and supported, and be made a part of the public school system. The first manual training schools were established by private individuals and they stood as object lessons to their communities and to the world. We all know how quickly their value was appreciated and how grandly their support has been assumed as a part of public education. It will be so with vocational or trade schools,

whether established for boys at the age at which they now leave school, or for young men from eighteen to twenty-four already engaged in mechanical work, as soon as there have been enough such schools organized by private means to serve as the necessary object lessons.

In no field of philanthropy or of generous endeavor is there a more splendid opportunity than here, or a probability of a greater return in lasting benefit to humanity for each dollar expended, than there is at present open to those public-spirited men who may come forward and set the example of establishing industrial schools in our larger and more important manufacturing centers.

Progress in Industrial Education.

Recently and especially during the last year the movement for industrial education has made a marked advance. This has shown itself in many ways—by the increased general interest and discussion of the subject and the appreciation of its vital importance; by the establishment of a considerable number of new schools; by the development and extension of the existing ones; and by the increase in attendance and number of applications for both day and evening classes in all trade and elementary technical courses wherever they have been established.

One of the most significant things in this recent development has been the establishment of the National Society for the Promotion of Industrial Educatoin which was officially organized last November. This was the result of a movement of a comparatively

few men who had long been interested in industrial education, who came together in an unofficial way to discuss ways and means of advancing it, and the feasibility of organizing such a society. At that informal gathering last summer it was unanimously decided to correspond with a large number of persons through the country who were thought to be in sympathy with industrial education and to get from them their judgment as to the wisdom and practicability of attempting to organize a national society.

The replies which came from nearly all of these sources were of such an enthusiastic character as to leave little doubt in the minds of those who constituted the original committee about the wisdom of carrying the plan into immediate execution. As the initial step in the organization of this society, invitations were sent out very generally asking everybody interested to attend meetings in Cooper Union, New York City, on November 16, 1906. There were two of these meetings, one held in the afternoon at which an official organization was formed, a constitution adopted, and officers elected, and a second—a publc meeting—held in the evening in the large auditorium of Cooper Union, at which Nicholas Murray Butler, President of Columbia University, presided. The things which most impressed many of those who were at these meetings were the character of the men present, especially at the afternoon meeting, the large attendance, and the attention and enthusiastic interest which was manifest in both the audiences.

There had been invited representatives of public and private educational work, manufacturers, repre-

sentatives of labor organizations and men whose interest was in social and civic betterment. All of these classes were well represented. Men and women had come from nearly all parts of the country, many of them traveling very long distances in order to take part in this movement and to give it their support. There were able addresses by a number of men of prominence at the evening meeting, but chiefly significant was the size and character of the audience that crowded the large Cooper Union auditorium. Not only was every seat filled but many persons were standing in the aisles and still more were turned away from the doors because of their inability to find even standing room. The contrast between the enthusiastic way in which this society has been started and has received support from very many directions, and the way in which many similar movements have come into existence from small and meagre beginnings, gives us every reason to hope that much useful and effective work helping toward the establishment and development of industrial schools will be accomplished by this latest addition to the list of national societies.

Many other evidences of progress have been observed since this Committee made its last report. Within the past year many other public meetings have been held with the object of stimulating interest or of gaining insight and information on some of the many problems of industrial education. A number of investigations have been conducted,—for if adequate means are to be found for furnishing suitable vocational training for any large portion of the great army of young people who receive but little direct

aid from our present educational system, it will require not one type of school, but many types fitted to the different needs and requirements of different groups of individuals and different localities. Some new schools have been established, and in those already existing there has been seen in many directions marked growth and development.

The committee would refer to:

The movements for the establishment of official committees and state commissions to study and investigate questions of industrial education.

The establishment in a number of places of new trade or elementary technical schools through private endowment.

The establishment in several towns and cities of day and evening trade schools as part of their public school systems.

The establishment, growth and development of special technical schools such as the textile schools of Massachusetts.

The extension, especially in industrial centers, of manual training in the public schools.

The opening of special classes for apprentices and journeymen and for foremanship in a number of colleges and universities.

The establishment of apprenticeship schools by employers in large manufacturing plants.

The systematic attempts by several large railroad corporations to train and educate their skilled workmen.

The growth and extension of practical and technical instruction offered by the evening classes conducted

by the Educational Departments of the Young Men's Christian Associations and similar associations.

Also the somewhat remarkable growth in the demands by young men for the instruction offered by the few trade and elementary technical schools that have been in existence for a longer period of time.

Under the first heading should be mentioned the State Commission appointed in Massachusetts in 1905 which has already made and published an important report containing the results of a valuable investigation conducted by Susan M. Kingsbury. Also a second Commission appointed by Governor Guild of Massachusetts in August, 1906, to serve three years. The purpose of this commission is to continue the investigation into industrial conditions and industrial education begun by the earlier commission, to provide lectures on the importance of industrial education, to visit and report on all special schools where industrial education is carried on, to initiate and maintain industrial schools and direct expenditures of money for the same, appropriated for their maintenance by the municipality or the state, to report annually the condition and progress of industrial education during the year, and to report at an early date on the advisability of establishing one or more technical schools or industrial colleges providing an extended training in the practical principles of the important industries of Massachusetts.

The time has been short, but the commission has already worked out a general plan for a type of industrial school closely related to both the public schools and the local industries, to be governed by

local advisory boards including representatives of the industries concerned, both employers and employes, so as to keep the instruction thoroughly practical. Their plan is necessarily flexible. It places the principal emphasis on the industry, but includes such instruction in drawing, mathematics, mechanics and elementary principles of applied science as are applicable. The plan makes provision for the possible completion of a longer course through evening or part-time continuation classes, for similar part-time courses for apprentices, and for evening courses for persons employed in mechanical occupations. A number of public meetings have already been held in the larger towns and cities of the state for the purpose of arousing interest and explaining the details of the plan.

The commission has also been continuing its investigation of industrial conditions at home and has sent a committee to Germany to study industrial schools there.

In some other states, too, interest has been aroused and some progress made in a movement toward the establishment of similar commissions; also in a number of cities local committees have been formed to study conditions and consider the advisability of establishing trade or technical schools.

Several private trade and elementary industrial schools have been recently started. The first which should be mentioned is the Carnegie Technical Schools of Pittsburg, with which all members of this Society undoubtedly are familiar. This school in its day courses for apprentices and journeymen, and in its

evening trade and applied science classes, is doing work of an industrial character. It was opened to students in the fall of 1905, and the enrolment of students in the various departments during the past year, according to the general catalogue for 1907–08, was as follows:

	First Year.	Second Year.	Total.
SCHOOL OF APPLIED SCIENCE.			
Day Students	178	77	
Night Students	168	192	
Preparatory Class	207		
	553	269	822
SCHOOL FOR APPRENTICES AND JOURNEYMEN.			
Day Industrial Course	36		36
Night Courses for Journeymen in Building Trades.			
General Course	22	22	
Plumbing	11	11	
Sheet Metal and Cornice Work	8	7	
	41	40	81
Night Courses for Journeymen in Machinery Trades.			
General Course	42	22	64
Night Courses for Apprentices in Building Trades.			
Bricklaying	11	13	
Electric Wiring	12	14	
House Painting	13		
Plumbing	21	23	
Sheet Metal and Cornice Work	11	11	
Sign Painting	12	10	
	80	71	151
Night Courses for Apprentices in Machinery Trades.			
Blacksmithing and Forging	8	11	
Machine Work	26	23	
Moulding and Foundry	11	10	
Pattern Making	20	13	
Chemical Practice for Foundry Foremen	15		
	80	57	137

School of Applied Design.			
Day Students	18	5	
Night Students	57		
	75	5	80
Margaret Morrison Carnegie School for Women.			
Day Students	70		
Special Drawing Class	10		
Special Millinery Class	24		
	104		104
Night Students.			
Bookkeeping	26		
Cooking	14		
Millinery	15		
Sewing	34		
Stenography	28		
Special Drawing Class	3		
	120		120
Grand total			1595

The new Franklin Institute of Boston has been recently organized to do work very similar to that which, for many years, has been carried on by the Mechanics' and Tradesmen's Institute at West 44th Street, New York City, which gives evening instruction in mechanical and architectural drawing, machine design, and in physics, electricity and other branches of applied science to large classes of working boys, to supplement the practical experience that they are getting through their regular daily employment. The Franklin Institute is not yet in operation but the buildings have been begun and the plans are well advanced.

Several other new trade-schools have been projected through the generosity of public-spirited citizens. Among these should be mentioned the Wentworth Trade-School of Boston, the new trade school at St. Louis recently founded by David Ranken, Jr.,

one in Denver, Colorado, and another in Austin, Texas.

There should also be mentioned the Milwaukee Trade School which was started about two years ago under the auspices of the Merchants and Manufacturers Association of that city to teach plumbing, pattern-making, moulding and the machinist's trades, and also mechanical drawing and practical mathematics. The school is thoroughly equipped with modern machinery of the highest grade and has an enrolment of about 110 pupils in its day and evening classes. The courses offered are short, less than a year in length, but the experience thus far seems to indicate that a more complete training can be obtained there in any of the trades offered in the short time mentioned than in three years of a usual apprenticeship.

Perhaps the most important instance of trade instruction as a part of a public school system is to be found in Columbus, Georgia. Here an industrial school has been started and is maintained by the municipality. The regular courses preparatory to this school include manual training in each grade of the primary school, or instruction in a Primary Industrial School in which white children mostly of the working classes are taught various kinds of handwork including weaving on miniature looms, along with other academic courses.

In the Secondary Industrial School the pupils are taught the mechanical arts and textile trades. The course includes machine and foundry work, carpentry and pattern-making; also instruction in all the operations in cotton manufacture from the picker through

to the finished product, both fancy and plain loom-weaving being taught. Training, too, is given for office help in stenography and typewriting and in cabinet filing; and for girls, work in home economics, domestic science, dress-making, and millinery. This school is thoroughly equipped with tools and machines for the mechanical trades, and has a complete equipment of cotton and hosiery mill machinery, so that it may make the instruction in the textile trades efficient. There are also physical and mechanical laboratories and similar facilities such as would be needed to make the instruction in other subjects equally thorough and practical.

The school aims to fit its pupils, immediately upon graduation, for some kind of practical work in which they will have an appreciable earning power. To insure this the students are required during the last year to work on a part-time basis in some establishment in the city, having the same hours, and working under the same conditions and regulations as the other operatives. This is done to show them as well as possible what is likely to be required of them after they leave the school, and to make them more reliable. In the course of time, it is the intention to enlarge the scope of the school and to include study of other trades, besides those which have been mentioned. Evening classes are also operated six days in the week during almost the entire year.

There are several other cities in which there has been some discussion and public sentiment aroused looking toward the establishment of trade schools as a part of the public school system, but, so far as this

committee has learned, in no other city has such a day school been actually started. Evening classes, however, conducted by municipal boards of education and supported by public expense are in operation in a number of places. Among these should be mentioned Springfield, Massachusetts, New York City and Brooklyn.

Altoona, Pennsylvania, through the initiative of the Pennsylvania Railroad Company, is trying a new plan in industrial education in its high school. The industrial department of the school has received a gift from the railroad company of tools and machinery that places its equipment far in advance of that of most technical high schools, and makes it possible for the school to give the most practical kind of trade instruction in this department.

A four-year course is planned which will afford opportunities for obtaining a more thorough and practical technical training than has, perhaps, ever been offered before in any public high school. In return for its cooperation the railroad expects to secure from the high school young men who will be admirably equipped to enter its shops. The city of Altoona secures a splendidly equipped industrial school, well adapted to the needs of its population, a fourth of which is now employed in the shops, yards and offices of the railroad. This new high school will probably cost, all told, not far from $400,000.

The establishment, growth, and development of the courses of instruction of the textile schools, such as those at Lowell, New Bedford and Fall River, Massachusetts, is another indication of the growing appre-

ciation of the importance and value of industrial education. The first of these schools receiving public support was established in Lowell only about ten years ago, but they are already almost universally recognized as being of the utmost importance and value alike to the very large number of young people who are employed in, or wish to enter, the textile trades, and to these industries themselves. The total enrolment in these three schools at the present time is over fifteen hundred students. Other textile schools have also recently been started at Lawrence and Ludlow, Massachusetts.

For a number of years the value of manual training as a part of general education has been very generally recognized, and as a consequence it has been introduced more and more into public school systems in the larger towns and cities throughout the United States and new buildings have been erected for the purpose; but more recently, and especially in large industrial centers, the value of manual training as a foundation for industrial employment has become more evident, and in a number of cities new schools have been built and equipped in which the purpose of a very large part of the instruction has been frankly technical, and in which the equipment installed has been such as to make a thorough and practical mechanical training entirely possible. As examples, we would call attention to the new schools that have been built recently in Allegheny, in Pittsburg and vicinity, and in Wheeling, West Virginia; to the new Technical High School in Springfield, Massachusetts; to the Manual Training High Schools

of St. Louis, Indianapolis, Kansas City, Chicago, Denver, Brooklyn and New York City, and to the new Manual Training High School which has been projected in Cleveland, Ohio.

A number of colleges and universities have recognized the demand for elementary technical and trade education, and, seeing the good which might be done if their laboratories and facilities were available for such instruction at night, have opened evening classes in technical subjects for those who are employed during the day. Others have been meeting the same kind of demand through short special courses conducted during the summer vacation. As examples of such work should be mentioned the evening courses for foremanship conducted at the Massachusetts Institute of Technology in Boston, the evening technical courses offered by Columbia University, by the College of the City of New York in New York and by the Polytechnic Institute of Brooklyn in Brooklyn; also the work done by the University of Cincinnati and by the University of Wisconsin.

Besides the attempts which have been made by public-spirited citizens and by existing educational authorities to meet the rapidly growing demand for better vocational training, employers themselves have also done much, especially during the past four or five years. A considerable number of large manufacturers have organized regular classes with systematic courses of instruction for their apprentices, draftsmen and other employees. These are as a rule conducted free of any charge and often on the company's time. The oldest well-known example of

a school of this type is probably the evening school carried on by the Hoe Manufacturing Company of New York City, but a more recent, and perhaps better known, example is the apprenticeship school conducted by the General Electric Company at their works in Lynn, Massachusetts. The work of this school has been fully described in the transactions of the American Society of Mechanical Engineers for 1906. During the past year there were about two hundred students enrolled. The National Cash Register Company of Dayton, Ohio, has a similar school with about the same number of students. There are a number of other similar apprenticeship schools in various industries, and the conviction seems to be growing that for a company to provide this kind of opportunity for training and educating the young men that it takes into its service is not only a duty which it owes to its employees, but is also a good business policy which pays when considered purely from the financial viewpoint. In this connection, too, there should be mentioned the Casino School, situated near the works of the Westinghouse Electric and Manufacturing Company, of Pittsburg, and conducted mainly for the benefit of their employees; also the Winona Technical Institute in Indianapolis, Ind., which is a trade school conducted largely by a manufacturers' association for the purpose of training competent workmen.

A number of large railroads, too, have adopted a similar plan. The most significant movement of the kind is that recently installed by the New York Central System, which has organized apprenticeship

courses on company's time in most of its large shops. During the past year there were about five hundred apprentices enrolled, and the work is rapidly being extended. Somewhat similar systems of training have also been adopted by the Atchison, Topeka and Santa Fe Railroad, the Pennsylvania Railroad and the Missouri Pacific Railroad, although on none of these lines is the plan as comprehensive, or the work as well organized as it is on the New York Central System.

The railroad branches of the Young Men's Christian Association which have been established in railroad centers for the benefit of railroad men, and for the most part with the active cooperation and support of the railroad companies, should also be referred to. Many of these have evening classes offering very practical instruction to the railroad men, which is especially adapted to their needs. In twelve of the largest of these there was last winter an enrolment of 1,423 railroad men.

Besides the many developments for the establishment of new schools and new opportunities for industrial or vocational training that have been referred to, there has been as well a marked growth in the older schools in this field of education. The committee has no general statistics regarding these schools to offer the Society, but from such schools as Pratt Institute of Brooklyn, Cooper Union of New York, Mechanics' and Tradesmens' Institute of New York, the New York Trade School, the Baron de Hirsch Trade School, the Manhattan Trade School for Girls, the Boston Trade School for Girls, the Williamson

Free School of Mechanical Trades, the trade courses in Girard College, the California School of Mechanical Arts and the Wilmerding School of Industrial Arts of San Francisco, come most gratifying reports of progress. In almost all of these schools there has been an increase in enrolment in all of the courses and an increase in the number of courses offered, and also an increased demand for the trained men whom they graduate. The work which such schools are capable of doing has become more widely known and as a consequence the number of applications for admission has multiplied rapidly. The following table giving those enrolled in the industrial courses in the Department of Science and Technology at Pratt Institute, Brooklyn, during the past ten years shows the character of this growth in one of these schools, but these figures may be regarded as typical. During this short period of ten years the total enrolment in these industrial classes has doubled almost twice, the total increase being nearly fourfold.

TABLE SHOWING ENROLMENT IN INDUSTRIAL CLASSES IN DEPARTMENT OF SCIENCE AND TECHNOLOGY, PRATT INSTITUTE, FROM 1897 TO 1907.

	97-98.	98-99.	99-00.	00-01.	01-02.
Day Courses	69	78	96	136	191
Evening Technical Courses	174	171	199	213	251
Evening Trade Classes	89	111	135	150	169
	332	360	430	499	611

	02-03.	03-04.	04-05.	05-06.	06-07.
Day Courses	222	241	256	284	339
Evening Technical Courses	293	356	403	491	556
Evening Trade Classes	206	222	241	282	297
	721	819	900	1057	1192

Note.—These figures regarding enrolment do not show the total increase in demand for instruction because of the increasingly great number of applications which have necessarily been declined on account of lack of room.

In preparing this report the committee has made no attempt to make it entirely complete or to include in it references to all the schools which should be included in any complete report. Its purpose has been rather to depict in a general way the increased interest and progress there has been in this department of education since the date of its last report.

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H. T. Eddy,
Edgar Marburg,
George F. Swain,
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Committee.

Note.—This report was originally presented as two papers by Professors Woodward and Williston of the committee. At the request of the Society, the papers have now been combined, supplemented and revised so as to form the Report of the Committee.—Editor.

THE STUDENT APPRENTICESHIP SYSTEM FROM A MANUFACTURER'S STANDPOINT.

BY A. G. WESSLING,
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The growth of the student apprenticeship system during the last few years has been so marked that it may well attract the attention of the men who are so closely connected with the students taking up such work, as are most of the members of this organization. The word apprenticeship carries with it the idea of an extended course of training as a preparation necessary to fit the apprentice for some particular trade or profession. In order to understand the necessity and objects of such an apprenticeship it will be well to consider the work for which it is a preparation.

Manufacturing concerns of the kind which maintain graduate student courses usually employ thousands of persons whose individual efforts must be correlated as carefully as are the various operations of a complicated machine. Such an organization may be likened to a modern newspaper printing press of the multiple deck type. The raw materials in the shape of paper and ink must be supplied as fast as required and not faster nor slower. If the ink is not fed properly, the printing will be unsatisfactory and the papers will not pass inspection. If too much friction is applied to the paper roll, the paper will tear, causing a delay until the tear can be repaired. If the

paper unrolls too easily the paper will double up between the cylinders, choking the press and sometimes necessitating readjustments of the pressure cylinders. The folder and cutter must do their work with the same regularity as the material is fed in. The delivery attachment must take the printed papers as fast as produced, just as the shipping department disposes of the finished product in order to make room for that which follows. The driving motor, corresponding to the power plant, requires frequent attention so as to avoid shutting down for repairs at inopportune times. In the printing press, the parts performing the various operations are rigidly connected by trains of gears. In the manufacturing company the interconnection of departments is not so rigid, but it should be just as certain and should operate with as little friction as is possible where human beings act as transmission members.

The manufacturing organization embraces several departments which may be classified as follows: treasurer's, publicity, legal, sales, engineering, manufacturing and construction. These are all under the direction of a single executive, the president, who in turn is responsible to the board of directors representing the stockholders. It is the duty of the directors to outline the business policy which is to be pursued, and they will naturally choose for president a man upon whom they can depend to carry out this policy. To successfully fill this position a man needs a thorough knowledge of men rather than of things or of books, and he should have that born quality of leadership which with a strong character inspires confidence and respect.

Since the company is in business for the purpose of making money, the treasurer's department may take first place in the order of attention. All departments require money for salaries, material and general expenses, and look to the treasurer's department to furnish it as required. In order to do so it is necessary to collect money as it is due, to guard against failure of collection by avoiding giving credit to irresponsible customers, and to save where possible. A cost department is maintained for the purpose of keeping account of all shop costs in such a manner as to quickly indicate what work is profitable and what is not. At the same time, the cost department acts as a check upon the design and upon the manufacture of any piece of work. The treasurer's department is obliged to furnish enough money to carry on the business properly, yet it must guard against having too much money invested in materials long before they can be used or in unproductive equipment.

The duty of the legal department is to see that contracts are properly drawn and carried out; that costly litigation is not invited by careless disregard of existing patents, that patent rights are secured to protect new inventions and to give legal advice to the other departments as necessity demands.

The publicity department must advertise the company and its products in every possible way to attract the attention of prospective purchasers. This work includes the preparation of advertising matter for publication in the advertising columns of the technical periodicals; it includes the preparation of articles

describing installations made by the company of sufficient interest to warrant their publication in the columns of regular reading matter in the same periodical; it includes the preparation of trade catalogs and bulletins, describing in detail the construction of apparatus manufactured by the company. The work of making public the name of the company and the quality of its goods should be done in such a way that the presentation of his business card by any representative would serve as sufficient introduction to any one who might be a prospective buyer.

The business of the sales department is to sell goods and this would be comparatively easy if the salesman could always offer exactly what was wanted, if he could promise delivery as requested, and if his prices were at least as low as those of his competitors. But such conditions do not exist, and it requires a first-class salesman to sell goods under conditions which are opposite to those given. When, for example, a generator is wanted of 325 kw. capacity at a certain speed, and the salesman finds that he can offer only a 300 kw. or a 350 kw. generator at that speed, he is expected to convince the customer either that the growth of the business will soon justify his buying the larger unit or that his machine of smaller capacity will have ample margin to carry the maximum load for the short period during which such maxima usually last. And in most cases a competent salesman will have little difficulty in securing sufficient data to enable him to present a strong argument in favor of one or the other of the courses given. A really good salesman seldom lets the price prevent his making a

sale. He knows that reliability and economy of operation are more important than a slight difference in first cost and he will point out to the customer those features of his machine which insure these results. In the district office, the salesman is frequently called on to act as consulting engineer, but he should resist every temptation to countenance poor engineering for the sake of making a sale. The district office salesman also acts as a means of communication between the customer and the manufacturing department.

The man in the engineering department must have not only a thorough knowledge of the principles of design, but he must have an intimate knowledge of shop methods, especially those in use in his own shop. He must be able to design a machine which will carry a certain load at a given speed without exceeding a predetermined temperature limit, and whose efficiency does not fall below a certain percentage; whose regulation lies within certain limits, and which, if it be a direct current machine, can operate sparklessly through a wide range of load usually equal to one hundred and fifty per cent. of its normal rating. In his design it is necessary to make due allowance for variations in the magnetic qualities of his material as well as for the usual inaccuracies in workmanship. And no matter how well his design may meet the conditions given above it cannot be considered satisfactory unless it can be manufactured in his shop at a profit. This should not be taken to mean that the engineer is responsible for poor shop management; it simply means that a design which can be successfully manufactured in one establishment may not be suc-

cessful in another place using different shop methods. And since satisfactory operation depends as much upon mechanical as upon electrical design, the engineer must give close attention to the mechanical design of his machine, and must see to it that poor workmanship is not allowed to spoil a good design. It will be evident that many years of experience and close observation are necessary to mature the judgment of an engineer to a degree which will make him competent to do what is here outlined. But the designing of machines is only a part of his work. He must keep himself posted in regard to the progress in engineering of all kinds and see what effect upon his work is likely to result from the development in other lines. He must make original researches in order to discover new facts or to settle doubtful questions. He must keep in touch with the demands of his market and try to foresee future tendencies. While keeping himself in readiness to adopt changes which are improvements, he must avoid taking up temporary fads. He is called on by the publicity department to furnish technically accurate descriptions of the machines built so that advertisements may be correct. Reliable information as to the heating and operating limits of all sizes and types of machines are asked for by the sales department. The manufacturing department insists upon his designs being made so as to lend themselves most readily to easy production under existing shop conditions, while the construction department demands that the machines be built so that they can be easily installed. If a certain machine proves unprofitable, the treas-

urer's department immediately concludes that the design is poor and asks that it be improved. And while he is busy trying to satisfy these many demands upon his time, the engineer is asked by the legal department for advice as to the value of patents which are for sale and is urged to exercise his own inventive faculties.

The manufacturing department has a number of subdivisions each offering opportunities to a man with an engineering education. The superintendent of the department must have great executive ability, which is but another way of saying he must be able to get other men to work hard toward a common end in the most efficient manner. He must be familiar with all kinds of machine tools and must know the capacity and limitations of every type. He must see that the most suitable tools are provided and that the tools are intelligently handled. He must know when to have jigs, templates, and other special tools made and when such are not economical. His assistants in the shop, such as shop foremen, may, or may not, be college graduates. Their ability as overseers is more important to their success than is a broad engineering knowledge. The man who does the purchasing should know how the manufacturing is done and should understand enough about the design of machines to appreciate the necessity of buying materials of known characteristics. It is not always advisable to buy materials at the lowest price at which they are offered; it is often of greatest importance to buy material of known quality for no other reason than because its quality is known, so as to insure certain

desired results. He must see that the material which he orders is on hand when needed, and on account of the many delays which occur, his work is not complete when the order is placed.

The man in the production department must see that the orders received from the sales department contain all the information necesary and this information must then be embodied in the shop orders in such a way that every department understands exactly what is wanted. He must know how long it takes to build every machine and must keep posted as to the amount of work in the shop so as to know what deliveries may be promised on new machines. In many cases, the time of delivery is of more importance to a customer than the price and a promise of short delivery will secure the order at a price higher than offered by a competitor, but, that the promise be met, it is usual to include a forfeiture and bonus clause in the contract and a promise of short delivery which shop conditions do not warrant, results in a considerable financial loss. The production department man must watch the progress of work in every department in order to prevent an order being delayed because it is overlooked or sidetracked. The man in the testing department must keep himself posted in regard to what machines are being completed in order that he may arrange his work to best advantage, and test several machines together when such combinations are possible. He must make his tests as impartially as though he were representing the purchaser of the machine, yet he must make sure that the machine is in proper con-

dition before beginning the test. He must see that the brushes are properly spaced and are properly fitted to the commutator, that the field coils are all properly placed and properly connected, that the armature is concentric with the poles and that it runs true; in fact, look after the many details which are possible causes of trouble and see that everyone is made right before making a test whose results are worthless unless everything is right. He must see that conditions are kept constant during the test, and keep an accurate record of conditions as they are. His work should be so carefully done that his results may be used by the engineering department with perfect confidence.

While the drafting department is really a part of the engineering department, its work is so closely related to that of the manufacturing department it may be considered here. The draftsman's duty is to make accurate and legible drawings for use in the shop. Since the same drawing is usually used for making the pattern as well as for machining the casting, it is necessary to show all dimensions; and, in order that these dimensions can be followed readily, the draftsman should know how measurements are laid off both in the pattern shop and in the machine shop. He should also understand a great deal about the work of a foundry in order that the cost of patterns and of castings may be minimized. While the draftsman may do no more than put on paper the designs made by others, there is at the same time an opportunity for him to make improvements in these designs, to suggest changes which will simplify either

the casting or the machining of parts, and to originate new methods of manufacture.

The work of the construction department is sometimes merely the installing of a completed machine; at other times it is the building up in place of a whole generating plant and putting the same into service. To do this requires a man combining the qualities of an engineer, a manufacturing superintendent and a diplomat, as the qualifications of the third person are often in demand in places where two or three contractors are obliged to work together.

Experience has proved that the only way to get men to satisfactorily fill the positions described above is to train men for them by means of some prearranged course. The young men graduating from college are not prepared to fill these positions at once, but their college course forms the proper kind of preparation to make them desirable as raw material from which properly qualified men can be made. In the organization with which I am connected (Bullock Electric Company), the students' course includes two years of work in the shops divided somewhat as follows: three months each in the controller, commutator, erecting, and assembling departments, four months in the winding department, and eight months on the testing floor. In these departments he begins work as a helper to one of the regular mechanics and is expected to conform to all shop rules and do the work assigned to him by the foreman. In the commutator department he begins by straightening segments, a monotonous and, to the novice, an apparently unimportant task. As he is obliged to work nine

and three quarter hours a day, the student is quite apt to become discouraged in a very short time if he does this work simply as a disagreeable duty which he cannot avoid. But if he takes an interest in his work and studies the reasons for building commutators in such a manner, and if he tries to master the art of straightening segments so as to become an expert, he will soon be allowed to build complete commutators and, at the same time, will be forming the habit of doing his best wherever he may be, which habit is the most potent factor in his future promotion.

When working as a helper, the student is respected for his ability to help and not for any theoretical knowledge he may possess. If he has learned to think, he may use his brains so as to become a more efficient helper even when doing such simple things as heating and carrying soldering irons. The student is in such close contact with the shop workmen that he gets an insight into their ways and their habits of thought which he could not get otherwise. During the time spent in the winding department, the student often progresses sufficiently to be put in charge of winding large stators for alternating current generators and motors, and he may have one or two helpers on such a job. Such work is quite interesting for he sees embodied in concrete form the principles of electricity which in the classroom were represented by formulæ and diagrams. He learns that a mistake in making connections results in a "hot coil" when the machine is tested, requiring the work to be done over and injuring his stand-

ing as a reliable workman. Carelessness in putting the coils into the slots is almost sure to result in injury to the insulation which causes a breakdown during the application of the puncture test. In this department the student has the benefit of the premium system and the bonus offered for doing certain work within a specified time urges him to work as fast as he can. But the temptation to gain speed at any cost is lessened by the knowledge that his mistakes will surely be discovered and as the time lost in repairing defects reduces his premium very materially, the student soon learns that reliability is much more important than speed. In the winding department he has opportunities for learning what windings are used in many sizes of machines; he can count the number of slots and measure their size and, if he is interested in checking the designs, he will have little difficulty in getting any further information he may need by asking for it. The natural bent of the student usually makes itself known in a short time after entering the shops. His future can be predicted with considerable accuracy from the report of any of the shop foremen after the first six or eight weeks. To the question, "How is So and So getting along," the general answers are given somewhat as follows: "I wish I had six more like him," and "The sooner you transfer him to some other department, the better I'll like it." A detailed report of the student's work day by day would not give a more accurate estimate of his probable progress, and, with but few exceptions, the reports from later foremen are in agreement with those of the first. During the

shop course, lectures are given to the students for the purpose of helping them to get as much out of their shop experience as possible. Shop methods are explained; the reasons for using certain forms of construction and their merits as compared with other forms are given; and the necessity of a knowledge of shopwork to the men in other departments is pointed out. Bulletins are distributed, and engineers and salesmen give talks relating to their particular lines of activity. Discussions of engineering subjects are encouraged and serve to bring out the individual's preferences and natural abilities. The students are given every opportunity to learn on the assumption that, the more a man knows about his work, the more valuable he will be to the company. While the student is learning the details of the business, the managers have an opportunity to take his measure and, when he is promoted, they know what his capacity is and do not put responsibilities upon him which he cannot bear.

During the time that our company has maintained a shop course for graduate students, I have carefully considered how their work was affected by their previous college training. The following are the results of my observations. College graduates are able to take up the work in any of the departments much more quickly than are men without education because their knowledge of engineering principles enables them to see very quickly what is to be accomplished by a certain shop process, and their understanding prevents any process from being merely a mechanical operation. The character of the student counts for

more than does the knowledge which he acquires at college. While the equipment of some colleges, both in regard to apparatus and instructors, is much superior to that of others, I am convinced that a good student will get more out of his course at a college with a poor equipment than will a poor student at a college with the best of equipment. The difference which is most marked in students from different institutions is their mental attitude regarding the value of shop experience. Some are always questioning its value, especially as applied to themselves, some take it as a matter of course, as though a certain amount of time had to be spent in that kind of work; while some seem to realize the value of the opportunity and try to make the most of it. Being fairly well acquainted with most of their professors, I cannot fail to see in these different attitudes the influence exerted upon them by their former teachers.

In order to lend my aid to promoting engineering education, I would like to impress upon all the members of this society the two following facts:

No college in the country can turn out full-fledged engineers, and the only way to become an engineer is to do engineering work. Impress these facts upon your students; impress them with the idea that their college course is but the training necessary to enable them to begin to study engineering; inspire them with a desire to become engineers worthy of the name; teach them that while but few can become Faradays or Maxwells, they can all help in the world's

engineering work by doing carefully and conscientiously the work entrusted to them. By so doing, the students will go forth—not handicapped by the idea that they know it all, but with a willingness to work and a desire to learn which will give them the best possible start on the way to becoming "*Engineers.*"

(For discussion, see page 474.)

THE SPECIAL APPRENTICESHIP COURSE.

BY CHARLES E. DOWNTON,
Foreman of Apprentices, Westinghouse Electric and Manufacturing Company.

The Westinghouse Electric and Manufacturing Company has two distinct apprenticeship courses, one for non-technical and the other for technical graduates. The former has been called the trades course and provides for intelligent young men who desire to become journeymen machinists, tool-makers, pattern-makers, foremen and inspectors. The other course, called the engineering apprenticeship, provides for young men graduates of technical schools and universities.

TRADES COURSE.

Manufacturing methods of former years have changed through the introduction of automatic machinery, specialization, and concentration of larger bodies of workmen under one management. The latter method does not permit of as close relationship between the apprentice and his employer. Personal contact, so helpful to a boy learning a trade, has been removed and the boy is dependent upon himself almost entirely for opportunities and, as a consequence, is often sidetracked through his desire to receive greater pecuniary compensation and the foreman's desire to have him become a productive unit.

To meet these changed conditions and to supply this all important guidance through personal contact,

the Westinghouse Electric and Manufacturing Company has organized a separate department aside from the other works-departments to look specifically to the welfare of each individual apprentice and direct him along lines which will make his apprenticeship service of greatest value. The department occupies the same position with relation to the boy that the employer did in the earlier days.

The work to which the apprentice is assigned is not intended to give him a general understanding but a specific training in the manufacture of a definite line of work, following a schedule which enables him to master the various machine tools; the work of the assembling floors for erection and fitting, and the bench for hand-work. This schedule is more or less flexible, changes being governed to a large extent by the boy's aptitude to grasp particular branches. Some are keen to do accurate work at the bench—others on the floor, while some show characteristics which will not permit of much advance beyond the operation of machine tools. There is need of each class, and the process of segregation is accomplished through the personal contact mentioned.

Many of the trades apprentices attend the Casino Technical Night Schools, where courses of instruction in mathematics, physics, mechanical drawing and shop-practice are taught by an efficient corps of instructors selected from the engineering departments of the Westinghouse Companies.

There is in contemplation a day school, to be operated in conjunction with the trades courses, where the apprentice will be taken from the shops two or

three days per week (two hours per day), to receive instruction in the branches named. This school will be in the works and will be in charge of an educational director.

Results achieved demonstrate that the old and eminently efficient form of apprenticeship can be maintained. Were such a system followed by all large industrial establishments there would be no danger of an undersupply of practical mechanics, quite as capable as those of the past.

ENGINEERING APPRENTICESHIP COURSE.

The average young man when leaving college has received the fundamental grounding in physics, mathematics, chemistry and the sciences which relate to some particular branch of engineering. He knows little of actual application and is deficient in that degree of working knowledge that qualifies him to be of immediate use. It is beyond the scope of any university to supply the practical experience which will mature men for efficient service immediately upon leaving college.

The college work should be supplemented by some sort of an apprenticeship service which will give the graduate systematic training in shop methods and a familiarity with the practical uses of materials as well as knowledge of the handling of men—to be gained only through direct contact and association with labor. In short, the scope of such a course should enable the graduate to obtain a knowledge of those essentials to a successful engineering career which in the nature of things are impossible to acquire at college.

The course must be planned to accomplish the gradual and systematic training of young men along lines which will give them a clear and definite insight into the products manufactured by the company, qualifying them to fill vacancies that occur in the working organization. The environments should be favorable for the development of powers of observation, alertness and decisiveness, executive ability, leadership, attention to details and commercial attributes, logical thinking and application of principles to a definite purpose.

In the course which the Westinghouse Electric and Manufacturing Company has organized, the apprentice is assigned to duty in the various manufacturing departments, where a comprehensive knowledge of the details of the apparatus can be gained through actual assistance and, in many cases, complete responsibility in its building; in the various testing departments to give a knowledge of the operation and capabilities of the apparatus; in the engineering departments to afford experience in the requirements and design of electrical machinery from a mechanical as well as an electrical standpoint. Some are assigned to duty in the correspondence, sales and other commercial departments, primarily as understudies and later, should they continue to show adaptability for the work, as regular employees. Care is taken to direct them along lines which appear to be suitable to their individual characteristics.

Proper facilities for further mental improvement are provided through The Electric Club, an institution which was organized in 1902 by the apprentices,

engineers and officers of the various Westinghouse Companies to meet the need for social recreation, mutual benefit and improvement, and the proper dissemination of electrical engineering knowledge. The various activities are managed by the apprentices through committees. The reception committee has direction of all social affairs, such as dances, smokers, receptions, musicals, and the like. The library committee is in charge of the library, reading, writing and lounging rooms. The lecture committee provides for lectures of a technical and general nature by the engineers and officers of the Westinghouse Companies, and by prominent visiting engineers. The section committee is in charge of the small inter-clubs. These clubs are limited in membership and were organized for the discussion of particular apparatus, such as direct-current and alternating-current controlling apparatus, alternating-current and direct-current generating and receptive apparatus, railway engineering and construction, protective apparatus, and the like. Each section is in charge of a leader and a recording secretary, chosen from among the members of that particular section, and a technical adviser from the older engineers of the department which has to do with the design of the apparatus to be studied. The limited membership causes better and more regular attendance, more enthusiasm through closer personal acquaintance, and better results in the choice of men for regular employment with the company.

The excursion committee provides for visits to the numerous industrial plants in and about Pittsburg.

This organization is quite similar to that of the sections, having a leader and secretary for each excursion party, which is limited to twelve, insuring better guide service and closer and more careful attention.

Our requirements are that the engineering apprentice shall continue on the work until he shall have prepared himself for filling satisfactorily a regular position in some department of the company's service, and when assigned a regular position before the expiration of the full apprenticeship service, compensation will be given commensurate with the ability displayed.

Of those who have left the course, fifty per cent. are now with the company. The others have various positions with operating and electrical supply companies, as consulting engineers, or as instructors.

Those with the company are distributed as follows:

	Per Cent.
Engineering departments	28.5
Erecting department	16.0
Commercial departments	33.0
Publicity departments	3.3
Price department	1.9
Works departments	7.6
Legal department	.3
Railway construction department	.3
British Westinghouse Company	1.8
Canadian Westinghouse Company	7.3

(For discussion, see page 474.)

THE ENGINEERING COLLEGE AND THE ELECTRIC MANUFACTURING COMPANY.

BY CHAS. F. SCOTT,
Consulting Engineer, Westinghouse Electric and Manufacturing Company.

The notable point of contact between the engineering college and the electric company is the engineering graduate. He is the product of the college and the raw material which is to enter into the human organization underlying the electric industry. What, then, constitutes the ideal graduate? What is expected of him and what training will best enable him to meet the requirements and the opportunities which will confront him?

The attitudes of both the college and the manufacturing company toward the graduate have changed greatly. Engineering laboratories and new methods of instruction show that the colleges are active and alert in appreciating the new needs. On the other hand, the manufacturing companies do not repulse the efforts of the technical man to find a job nor do they expect the graduate to be a ready-made engineer. They provide systematic courses for supplemental training, to which they welcome college men. Probably in no other field has there been such a growing demand for engineering graduates as in the electrical profession. This demand has been a great stimulus to engineering education and it puts to a severe test the efficiency of the schools which are to furnish these men.

What, then, are the departments of work for which college men are wanted? The popular answer a few years ago was: for inventing and designing. Such an answer to-day is wholly inadequate. There is scarcely a department in the large companies, whose forces number tens of thousands of men and whose business aggregates millions of dollars per month, in which there is not opportunity for the man with engineering training. The principal fields of work are the design and development of apparatus, the testing both of commercial and of new or experimental apparatus, investigations regarding materials and manufacturing processes, the inspection of materials and apparatus, manufacturing, the installation and erection of apparatus on the customer's premises, conducting the office work and correspondence between the works and the customer, which usually requires a broad engineering knowledge and good business ability; commercial engineering, or the specific application of apparatus, selling, and the various positions requiring executive ability, preferably with a knowledge of engineering matters. It is primarily to secure the personnel for the rank and file and for the leadership in these various departments that the company provides a large number of college men in a training course from which it may draw. It also furnishes men for various operating and engineering positions. This course, moreover, has not been established for sentimental reasons, simply as a part of an ideal educational system, but as a matter of necessity. The men need this experience and training and the new point of view which it gives before they are useful,

and the company adopts this means of getting its supply of men.

I have interviewed a number of my associates in different departments, proposing questions substantially as follows: What are the deficiencies of the college graduates? What is it that prevents the success of many of them? What could be done in the technical school to obviate these faults?

The first reply that one man made was: "There are as many answers as there are apprentices." While the replies which have been given to me vary in particulars, in certain features they agree. First of all, one thing is emphasized by its absence. No one has mentioned any lack of theoretical or technical knowledge. Only one man mentioned this point and he said that the schools give the men more theoretical equipment than they need. On the other hand, all agree that there is a deficiency in other things. One says that there is a general mediocrity and lack of ability to do large things; another, that there is a lack of initiative and ability to carry a thing through independently; another that the faculty of attending to details is not developed; another says that the lack of diplomacy and facility in getting along with other people is a leading fault; and another, that most men do not take a real interest and are not willing to stay with one thing long enough to really get something out of it, but are continually wanting something different as soon as the novelty has worn off. Most of the men are in too great a hurry.

Several referred to instances in which young men have declined to take minor work, although their supe-

riors had a succession of positions which were to follow successful performance. It was inexpedient to explain these plans to the young men. In fact their failure to undertake and do the little things well proved that they were not made of the right kind of stuff.

Suggestions by several of those with whom I talked were made with regard to college work. Students should be thrown more upon their own responsibility. They should be trained in making free-hand sketches, which cultivates observation and ability to see details. Engineering students usually hate rhetoricals and language courses. They should remember that engineers are sometimes called upon to fill positions which are worth more than $75 per month, and that in such positions they will need to know how to speak and write the English language. Students should see things from the practical rather than the theoretical or academic point of view. They should get into actual work during vacations or by devoting a year or two to practical work before completing their college course. They should be given the commercial or business point of view. Professors should be practical men. Engineering courses should discriminate between men who will take up pure engineering and those who will follow commercial work, the latter being given more of the allied and practical sciences and less theoretical training in mathematics, design and the like.

One of the gentlemen with whom I talked has had an exceptionally wide experience with young men and gave his views substantially as follows: "Graduates

are not 'handy' men—they are not apt in doing things. They are students, but are without originality or initiative. Mr. A. was an exception. When he was in the test room and was told what was wanted, he was able to devise his own methods for finding out the facts necessary to prove or disprove the point in question. Mr. B. and Mr. C. were good men on experimental work. They knew how to hang on, to think independently and to go and do things. Mr. D. was an able man on the installation of new apparatus outside of the factory. He was capable of taking up a new and difficult problem and settling it. Such were the early characteristics of four men who have now attained prominence. What is wanted is the faculty of being able to tackle a subject and find out something independently; independent thinkers are not tied down to books. Textbooks in general are based upon what has already been done. They are historical and are several years behind time. Many engineering tasks are like ordinary problems in mathematics. The solution given in the books is only one solution. There are usually others. Many who are able and willing to do things are tied down because experience or precedent sets the limits beyond which they are unable to go. They cannot devise new ways—aside from the ability to invent or devise new things there is the faculty of accomplishing the same result in a superior manner by improved methods. Engineers should be able to recognize the conditions which exist; then to formulate the problem, and then to solve it."

Such is the gist of the views which my associates

have expressed. Conversations which I have held with men from other companies indicate that these views are not local but are general.

Now all this sounds quite commonplace. Most of the statements suggest sentences from some "Handbook for Young Men" or "Guidebook to Success." All my friends treated the problem as a serious one; in fact, with many the securing of able assistants was one of their most serious problems—and yet their statements, the summary of their experience, are easily resolved into a few time-honored platitudes. Possibly these platitudes summarize the experience of others and we now simply emphasize their truth by discovering their meaning.

In trying to generalize these various views and experiences, it seemed to me that they simply presented the different phases of some general condition which should admit of a simple statement. The fundamental difficulty is *lack of adaptation to new circumstances and conditions.* This suggests a biological expression. The man fails to be "in correspondence with his environment." We may press the biological analogy still further, for we are simply considering one phase of development, the growth of the individual to form a part of the larger industrial and social life.

First of all, the individual must be capable of true growth. In nature things result from growth or from accretion—the animal grows, the crystal increases; one lives, the other does not; one assimilates new material which becomes a vital part of itself, the other adds new particles to the outside. Some men

absorb and assimilate knowledge; others store it away in memory's pigeon holes. Some men assimilate experience—it broadens them and adds to their powers; others gain no more than the simple ability of exact repetition. Encyclopedias are useful, and so are human machines, but they lack the vital principle of growth.

A paragraph from "The Natural Law in the Spiritual World" applies to "The Natural Law in the Engineering World."

"As closely as possible we must follow the broad, clear lines of natural life. And there are three things especially which it is necessary for us to keep continually in view. The first is that the organism contains within itself only one half of what is essential to life; the second is that the other half is contained in the environment; the third, that the condition of receptivity is simple union between the organism and the environment."

The first great factor is heredity. It fixes the initial capabilities. As the infant enters life with certain capabilities inherited from his parents, so the engineering graduate enters active life with certain initial capabilities. He thus inherits from his alma mater certain acquired knowledge and habits and intellectual powers, and his capacity for future development of the powers which nature has given him are largely determined by the training which the foster mother gives.

Just as an "organism must either depend upon its environment, or be self-sufficient," so also must the graduate. In order to grow he must have environ-

ment—it is commonly called opportunity—and he must be able to adapt himself to it efficiently.

"To seize continuously the opportunity of more and more perfect adjustment to better and higher conditions, to balance some inward evil and some purer influence acting from without—in a word, to make our environment at the same time it is making us—these are the secrets of well-ordered, successful life." Such is the principle laid down by the biologist, and what he applies to life in general applies also to the engineer.

If I have correctly understood my associates and generalized their views and have properly applied certain biological principles, then it follows that the future usefulness of the engineering graduate is determined by the laws which underlie natural life and growth. The engineer deals with nature's materials and forces; his own development must follow natural laws. The engineer has laid the material basis for modern civilization and large achievement through cooperation; he himself must cooperate, he must be in correspondence with his environment.

Various conclusions are easily drawn. If a school would develop a man and not a technical machine, it must train men to think and to do rather than simply to know. It must not only develop the individual, but it must also train him in efficient relations to his environment. He must be able to apply his knowledge and use his powers; *i. e.,* he must be practical. He must be trained in observation and judgment regarding his environment; *i. e.,* he must have common sense. He must be able to think straight and to

include all the premises. He must be able to harmonize himself with the things about him, in order to act effectively; he must have originality, initiative and independence. To work effectively with those about him, whether superiors, or associates, or subordinates; he must understand men. Hence, his education should be one not of engineering subjects only, but should include the humanities; nor must his education be one of books alone, he should enter into active life with his fellows.

Education has concentrated its efforts too much upon the individual, in the endeavor to store his mind with facts and to develop skill in intellectual gymnastics. It has neglected the qualities which insure sympathetic and efficient relationship between the man and the world about him. This is really what we mean when we say that education is too theoretical and is not practical. We do not underrate knowledge and training, but we want them to be of use. First is individual ability; second is appropriate environment; and third, and equally essential to efficient outcome, is the correspondence and continual adjustment between the two. We want men who can see the situation and fit themselves to it.

The progress of the nineteenth century rests upon engineering accomplishment; the promise of the twentieth century calls for engineering work of a higher order and a wider scope. The future engineer must be a larger man. In contact with a great environment, the resources are limitless. The possibilities and the outcome depend, therefore, upon the ability of the man for harmonizing himself with his environ-

ment, and the more complete and efficient this adjustment the larger and more useful the life.

Joint Discussion.

Mr. Milan R. Bump: Within recent years the subject of practical training along definite lines as a supplement to technical education has become one of considerable importance. The large industrial concerns were first to recognize this plan as a necessity in maintaining efficient and capable operating and engineering organizations. Within the past ten years this plan has extended to practically every industrial concern of any prominence. More recently gas and electric central-station men have come to see the necessity of a similar line of cadet training. With the constant advancement in operating, new business and accounting methods, it has been found necessary to fill vacancies from within the organization in order to secure best results. This is particularly true of syndicated or associated properties which have their own systems of management.

The gas industry had been for many years in the hands of the so-called "practical" men who were antagonistic to the invasion of their field by the engineer. The result was that the gas industry, four times as old as the electrical, was many years behind in engineering and scientific development.

With the increased number of properties in associated management and the building up of accurate and complete accounting systems and operating systems and of an entirely new and unheard of plan of increasing the business, it was found

to be almost impossible to fill vacancies in managerial, superintendent or engineering positions by men who had not been trained in the methods used by the companies. This led directly to the idea of building a training and development department from which promotions are made. The plan of this department, which is conducted at the plant of the Denver Gas and Electric Company, is as follows:

An organization known as the "School of Gas and Electric Practice," whose officers are the officers of the company, was established. One of the engineers connected with the company makes a trip each year to a number of the enginering colleges and selects from among the applicants those who seem best fitted to our needs. The men are hired at a nominal salary and sign a contract to remain with the company or its associates the full two years which the training period covers. Transportation is furnished to Denver and upon arrival there the men are assigned to one of the various operating departments, such as meter testing, transformer, street gas-main, gas-range setting, works operation, distribution office, new business, etc. They spend time enough in each department to become familiar with its work, and at the end of two years have covered nearly every essential branch of the operation of gas and electric central-station companies.

In addition, two class meetings are held weekly and lectures and papers are presented by the operators, including every superintendent, foreman, head of department and specialist connected with the company. Two technical instructors are provided to assist in

preparation of lectures and in bringing out the important details. The lectures cover every phase of the work of the company and the men are expected to go over the notes and papers presented when in the department covered and become thoroughly familiar with them. A reading room is provided where a small library of the best books on the various subjects is being collected.

At the end of two years or more, often before that time, the men are assigned to operating positions with one of the companies and a careful watch of their work is kept to assist in selection for future promotions.

The selection of men suited to the work is of extreme importance. They must be men who can gain the friendship of every employe of the company in order to get from them the practical information which will make them valuable. They must be men who can meet the public properly in order to assist in promoting the welfare of the company by the settlement of complaints, the securing of additional business, etc. The day when any central-station company can afford to wait at their offices for business to come to them is past forever. The central-station man of the future must be a commercial engineer as well as an electrical or a gas engineer. The real engineering lies in the proper handling of the company's funds. Many engineers do not or cannot see that money expended to secure small plant economies could often be better expended in extensions and the promotion of new business. Some plants earn four to ten times as much as others with equal possibilities. The dif-

ference between the two is largely a matter of commercial engineering. There is not now and probably never will be a plant which has all the business possible to secure, but it is the man who realizes this that strives to attain that desirable end. Ability to distinguish between profitable and unprofitable business as affecting station investment, etc., is one of the essential duties of the engineer. Certain classes of business are often more remunerative than other business taken at three or four times the rate per kw. hr. The average college man does not see the application of engineering to these problems. Most colleges are, I believe, lax in the matter of training men to realize that it is the application of engineering principles to commercial business that offers the greatest field for the future. I believe more attention to training of men along the elements of accounting and accounting methods would be a great benefit to most college men.

There are extremely few men who gain fame or fortune through engineering alone, while there are thousands who succeed in the combined commercial and engineering field. Many of the men we receive have a sort of contempt for accounting and office work, but the engineer must master these branches in order to succeed.

I sometimes think the central-station engineer is expected to know more about more different things than any other engineer. The field offers many chances for specialization and it has been found very beneficial in certain cases to allow men who so desire to become specialists along certain lines, such as gas distribution, power solicitation, etc.

While the work as applied to central stations has never been installed on as large a scale as some of the industrial concerns, I feel that the men have profited more by it, and that the future requirements for men can be met very satisfactorily in this way, and in no other way can the same results be attained.

We hope to cooperate with the colleges in the future even more than we have in the past, and in conclusion wish to invite the college men to become familiar with what we are doing and aim to do, and to offer our services in any way that will assist in giving the technical graduate the best insight into proper practical realization of technical training. We realize that the technical graduate fresh from college is raw material, but that with a given amount of effort on our part we can do for him and he can do for us much more than the man who has not had the advantage of a technical education.

Mr. Russell: Credit is due the manufacturers for the development of such adequate systems of special apprenticeship, and the men in charge of these systems should be congratulated on being able to turn technical graduates so quickly into paying investments. The average graduate will not fit directly into a commercial organization; in fact it usually requires two or three years for him to get into step with actual conditions as they exist in manufacturing and railroad shops. The graduate has become so accustomed to being treated as a student that this treatment must be continued in some measure by the manufacturer. He will not be content on work that appears at all routine, but must have variety. He

expects to be able to apply calculus at once to something new and original; he naturally feels that he has invested several thousand dollars and a number of years and therefore is already well started on a commercial career.

The three papers read illustrate the quickest way to make use of the technical graduate. The method prescribed is, first to create an atmosphere in the commercial plant as near that of the technical school as possible; second, to place the young man under a technical man who can appreciate his makeup and who will make his work pleasant; third, to use him in lines of work similar to those of his school course; fourth, to give him a variety of shop, drafting room and testing experiences; in short to make him a special apprentice. It is a plain business proposition and not only does it pay almost from the start, but young men are gradually assimilated by the organization.

This plan is successful with manufacturing plants like those referred to, but is limited in operation to large plants and appears to be chiefly useful with graduates in electrical engineering. There are a large number of plants and railroads who need mechanical engineers to run their shops and handle their men, but who are so organized and engaged on such a class of work that an atmosphere suitable for the cultivation of the special apprentice cannot be created. It is with these, the vast majority of commercial plants, that special apprenticeship, at least as far as mechanical graduates are concerned, is a flat failure.

PROFESSOR MAGRUDER: Why have the special apprenticeship systems failed in such plants and railroads?

MR. RUSSELL: This was well expressed by the master mechanic who said "special apprentices play around the edges but never get into the game." One reason for this is that the special apprentice is always treated as a student and does not stand on his own merits.

Mechanical engineering courses are receiving criticism at the present time which cannot be overlooked, as it is friendly criticism and comes from the graduates themselves. They are asking whether the technical schools do not need to change the details of their training so that graduates may fit more easily into commercial organizations. As indicated by the papers read, the manufacturers have come the whole distance in making the graduate useful, should not the technical schools go part way?

Thus far the interesting plan being carried out by the University of Cincinnati shows no change in the character of the courses, but there is no question but what the close association with shop practice will soon suggest changes in the courses, as it has already called for more exacting information from the instructors. Often the technical man is excelled in the handling of men by some practical man who knows much less, and whose only training has perhaps been a correspondence course.

PROFESSOR MAGRUDER: Is that not a question of executive ability? Is there any way in which a college professor can put executive ability into a man's head at eighteen years of age?

MR. RUSSELL: A large part of the problem is a question of attitude, and the attitude of a graduate is the direct result of his training. Reference has already been made to the more practical views of the graduates from certain colleges due to the influence of the professors. A boy with no training whatever will fit into a shop organization at once. The secondary technical schools are turning out a class of men who assimilate at once. Granted that no school can supply common sense, there nevertheless is much that a technical school can do to develop an attitude toward work that will make not simply the pure engineer, but also the broad type of commercial engineer.

DEAN KENT: I have in mind a member of my class who was one of the poorest men in the class in Stevens Institute. As a student he was in for having a good time, and after graduation he became a special apprentice in the Pennsylvania Railroad service. He had the most rapid advancement that was ever known in that service up to the position of superintendent of motive power of the lines west of Pittsburg. Another man of the same class started in as machinist at fifty cents a day, and before many years he was superintendent of motive power on the lines east of Pittsburg. I know many special apprentices who have gone into railroad service and distinguished themselves in spite of their poor scholarship and lack of training. They got the opportunities and made use of them. The conditions of success depend on the personal qualities of the man, and on the opportunities that he gets. Sometimes one of these is

lacking, and sometimes both. I know of specially good and able men, capable of rising to the highest position, who have not been treated well in the apprenticeship schools and who left in disgust. The apprenticeship courses will have to improve in some respects. Some of the people who are giving apprenticeship courses think they are doing a great favor in taking a man and giving him an opportunity as apprentice and then raising him after two years to eighty or one hundred dollars a month. There are two or three such places for every graduate. You can not expect a man is going to stay long at forty dollars a month with no chance ahead of him because he is not favorably looked upon by the foreman of apprentices. I know many who have gone into such courses and left in a few months, and succeeded very well in other places.

Professor Emory: I believe we have occasion to congratulate ourselves on having seen a change in the last twenty years in the attitude of manufacturers. I remember when manufacturers would not look at our technical work. They made fun of it. Now eminently practical men go so far as to tell us in what particulars they wish us to improve the system, in detail. I remember when we could not get such excellent papers as these presented. But let us bear in mind in making changes in our courses, that the function of the engineering school and the university will remain for some time to teach principles, since principles are eternal but practice varies.

Professor Wood: I raise the point as to whether technical schools have not gone at least half way in

the question. We sometimes hear the request from the manufacturers to go all the way and to fit men for their special work along special lines in some special way. "We wish you would fit your men so that they can go into our work just as we want them" are the words of one. I reminded the man that his was only one of a hundred manufacturing establishments that had called for men in the course of a few months. Every engineering teacher must decide which is right for the technical school—to go all the way—or to maintain what has been traditional among the old and honored educators of the last twenty-five years and hold some to principle before we give it all over to the purely commercial interests. There is no broad-minded teacher of engineering but who would, if time, experience and energy permitted, teach a great deal more of the applied. But there is a limit to making the thinking side, the educational side, the brainy side, a mere commercial enterprise. While fitting men to earn a living, will the technical schools not hold to making men for the broad and disinterested purposes in education? The fair-minded and reasonable attitude shown in the papers and discussions of the representatives of the industrial side is evidence enough that the above remarks do not apply to such concerns as are represented at this meeting. The ideal condition would be where every graduate fits into the industrial work after leaving college without that discontent so common the first year or two. To accomplish this may require readjustment of the courses but I question if it demands compromise of any standards of education.

Professor Maurer: One speaker emphasized the point that our graduates do not stick in the apprenticeship courses, and led us to infer that we might prevent that by creating a proper state of mind. It has occurred to me that these papers might be made the means of effecting this. It seems to me part of these papers would make splendid reading for our senior engineering classes, and I suggest that the council or some committee of the society consider the feasibility of printing them for distribution among our senior students.

Professor F. C. Caldwell: The discussion so far seems to indicate that there is considerable difference of opinion between the college people and the manufacturers as to what the training should be. I do not think that the papers give any ground for such feeling. My own experience has been that, as a general thing, the manufacturers are on the whole very well satisfied with the training that the students are getting. There are one or two things, however, that should be remembered. It is undeniable that a great deal that is valuable might be given the students, which we do not give them. Every once in a while we hear suggestions from manufacturers that this or the other thing should be given more weight in the courses. They should remember, however, that we only have the men for four years, and putting anything else in the curriculum means taking something out. We very seldom hear suggestions as to what we should take out. I think a suggestion to put something in should always be coupled with advice as to what to take out. Per-

haps we ought to make more changes than we do, but I believe we are filling the needs pretty well.

Dean Kent: I have attended a meeting of the alumni association of Stevens Institute of Technology where this question was discussed. Many of these alumni are now old heads of maufacturing establishments, employing many graduates. The question was raised, "what difference shall we make in the course at Stevens Institute? Would you like to see any change made?" The answer was unanimous, "do not make any change, it is all right." Do not specialize. Teach the fundamentals and teach them strongly, and let the men specialize after graduation.

Dean Woodward: We ought not to be so easily swerved from our courses. I have heard "practical" men complain that graduates of schools do not know all the details of a particular kind of business, such as market prices. Those are the very things that technical schools should not try to teach. They are matters that change from day to day. There is enough to give to the men of things that do not change. We should not pay much attention to this shallow criticism, and yet we want to take these things kindly.

Professor Williston: To some extent I agree with the last two speakers, and yet I cannot help feeling that there is a large foundation of truth in many of the criticisms which come to us from manufacturers which have not been fully understood by us all. As I have come in contact with manufacturers, and have listened to their criticisms of the men who are graduated from engineering schools, their comments have

not been that the men did not know this or that technical detail. Nor have they said that they did not happen to know the kind of fundamental principles that Professor Woodward just referred to. They have not said that they did not understand some eternal truth in mathematics, but rather that they did not have a certain kind of *human* common sense, that they did not know how to adapt themselves to new conditions, that they were unable to adjust their personalities to the wishes and desires of their superiors, and that they did not know how to take off their coats and cooperate in an efficient and disinterested and unselfish way with the organization for which they were working.

My observation coincides exactly with this criticism. The young men graduated from college have had four years of intense training while there, and before that from eight to twelve years of preparatory training, in which the one thought has been that of receiving information and benefit. Their purpose, while laudable, has been always selfish. Their thought and their instructor's thought has been "How much can we get?" Hardly once has the idea entered their minds, "How useful can we make ourselves to somebody else?" "How can we be of more service?" On the football field they develop a high efficiency in *team play,* and learn to subordinate themselves as individuals for the good of the team, but they are apt to enter manufacturing establishments with the idea of getting experience which will be of value to themselves, and with the idea of doing the work that is assigned them as they believe it ought

to be done. They do not realize that until they have learned to work first for the success of the corporation, and only secondarily to consider themselves, and also have learned to subordinate their own ideas and beliefs to the wishes and desires of their superiors, that they can really be efficient. They do not realize that in business *team work* is the key to the success of the whole organization. As Mr. Warner said last night,—"Few of the men who get into manufacturing establishments have tact and diplomacy." At school certain ideals have been held up before them as the only ones by which success could be attained, and after they are graduated it is often with the greatest reluctance that they are willing to accept or adopt any others. For these reasons there are a large number of good places where manufacturers are to-day unable to use to advantage the majority of the men graduated from our engineering schools, and on the other hand there are a great many graduates from good schools who have been for years in unimportant positions where these failings are of little consequence.

I know, for example, a number of men who have gone into the mechanical department of the Pennsylvania Railroad, and yet very few have been able to adapt themselves to the requirements of the road. And yet there have been better openings ahead for the few who have succeeded than there have been in lines of work into which the greater number have drifted. The same is true on other railroads. To-day there are very few graduates of engineering schools in the mechanical departments of any rail-

roads. I mention this merely as one illustration. In many other departments of manufacturing and industrial work the same statement would be true. The difficulty is more a lack of *human engineering* on the part of the graduate than it is lack of technical knowledge. If the college courses had been more efficient in training men to "give out" as well as to "receive" and to adapt themselves to whatever conditions in which they may find themselves, more college men, I believe, would have found their way into those places to which I have referred, in which at present there are but few.

I think therefore that we should take such criticisms as have come to us most seriously, and not be too certain that we are already meeting in the best possible way the full human need of those who come to us for training.

PROFESSOR WOOD: Do you think that the reason the Pennsylvania Railroad put so much money into the Altoona school is because our technical schools are not supplying the right kind of men?

PROFESSOR WILLISTON: I would not say that it was for that reason alone, but, on the other hand, I believe that the Pennsylvania Railroad officials do feel that the colleges do not provide them with the kind of men which they can readily use in their mechanical departments. The colleges provide men that can be admirably used in the civil engineering departments of the railroad, because there there is not a great body of untrained men with whom they must mingle, and to whom they must adapt themselves. In the civil engineering departments the college men can be largely separated

from the operating organization until the railroad itself has had a chance to give them the *human training* that they lack and the right attitude toward their work. In the mechanical department of the railroad it is not possible to segregate the college men in that way.

One reason why the large electrical companies have had so much better success in using college men than many mechanical manufacturing plants is because there is in the testing department of such companies an opportunity to separate the college men into a group where they can be treated half as school boys, half as employees, until they can be trusted to mix with the other men. It seems unfortunate that during the period of four years at college, while a young man is obtaining his education, that he does not have an opportunity to obtain also a training which makes it possible for him after he leaves college to mix with other men without having to pass through this period of adjustment and apprenticeship.

DEAN KENT: What change would you suggest in the college course to meet that complaint?

PROFESSOR WILLISTON: I feel we should take the criticism more seriously and not feel too sure that we are on the right track and that they are altogether wrong.

PROFESSOR MAGRUDER: What is going to be the effect on our upper classmen of having the special apprenticeship courses? We are visited every year by several gentlemen, men holding important positions in their companies, asking, and occasionally urging, that our graduates come to them. Their number is in-

creasing rapidly. Competition over the young graduate is becoming keener. The wages offered have increased from a minimum of ten cents an hour to seventy-five dollars a month. The result is that even average men receive several offers of permanent employment with some of the best companies at what most of us consider as good wages. Hence, unless the young and inexperienced graduate has wonderful control over his imagination, it is more than likely that his bump of conceit will become slightly enlarged. I am therefore a little skeptical about the wisdom of this phase of these special apprenticeship courses. While I am glad to cooperate with these gentlemen in every way that I can, I want them to remember that there is also a reflex action upon the college and the student, due to their offers.

Some students may be good lesson-getters and have many good qualities, but apparently be absolutely devoid of common sense and tact. We are often puzzled to know whether we will be justified in recommending such a man for his degree. We are unable to pump common sense or executive ability into a man. We can advise him, scold, jolly him or coddle him. Some men are born that way, and they need quiet, persistent, sympathetic treatment. In such cases the special apprenticeship courses are not to be preferred.

I have had some experience in supplying technical graduates to the railroads. I find that the lack of sympathetic treatment and personal appreciation and suitable remuneration tends to discourage the young graduate. While he may be getting excellent, practical experience, he sees nothing ahead of him except

a very mediocre position and at a very low comparative wage. Do you wonder why men are not rushing into some of the special apprenticeship courses?

I believe that one reason why certain of the electrical manufacturing companies have succeeded in training their technical apprentices for positions of responsibility is the sympathetic attitude of those having the apprentices in charge. The latter are systematically instructed and not allowed solely to drift. This same cooperative sympathy should be extended to the colleges.

Mr. Wessling: The chairman in opening this discussion seemed to apologize for the papers, by making the statement that they were prepared by college graduates. I do not quite see the necessity for the apology.

The Chair: I wanted this audience to understand that these papers were written from a sympathetic point of view. It was not intended as an apology.

Mr. Wessling: It struck me as such and I could not understand it, for I have not expressed any strong criticism in my paper. I have found among college professors a wide divergence of opinion as to what the students should be taught during their course. I know of some who think that a graduate should be ready to fill a good position immediately and for this reason they direct their energies to teaching certain kinds of practical work. I don't agree with that policy. It is not the best from the engineering standpoint nor from the standpoint of the greatest good to the engineering school. The purpose is to train engineers, and engineering rests on a broad foundation of fundamental principles which are true all the time.

Their special application can be better taught in the shop, and in a comparatively short time if a man has a thorough grasp of the fundamental principles. It is like building on foundations that are big enough to stand anything you want to put on. You do not have to put ten stories on at once, you can put one story on at a time and do as you please, because the foundations are there for whatever you wish to add. As to the question of salary, the young man who is looking ahead to his life's work rather than what he shall get, must make up his mind that he has to get some practical experience. He must bear in mind what value that experience will be to him later on. If he wants a big salary in the start, he will specialize at once, and his services in the special line will not be worth much. The pay is in proportion to what he can do. The man that takes the apprenticeship course must wait for the future. He is taking that course as an extension to his college education. I would not advise Professor Magruder to urge any student to take an apprenticeship course. Let the man make his own choice. Impress upon the student the fact that if he wants to become an engineer he must get a certain amount of real practical experience outside of the college work, and while getting that he must not expect to get a big salary at the same time. Let him go in, as Professor Williston puts it, for team work, and seek the place he is best fitted for. Self-forgetfulness is what is required. Let him do what he has to do in the best possible manner, letting the future take care of itself. A student will find in this apprentice course that the man who is constantly thinking of salary is the man who does most of the worrying

about his salary. The man who forgets salary and is interested in his work is the one who keeps his employer thinking about his salary and busy planning how he will keep that man who is so valuable.

Mr. Downton: Professor Magruder remarked that representatives of various companies come to the colleges to plead and beg the young men to accept positions with them, and that even average men are offered the choice of several positions upon the completion of their course, and as a consequence are somewhat elated. We must know the kind of work and salary offered to give us any conception of what it requires to give the graduate the swelled head. Speaking for myself, I cannot see why an offer of an apprenticeship course at thirty-seven dollars per month should swell the head of anyone. We offer opportunities. The scope of our work is broad and suitable to the varying characteristics of the graduate, and the work supplements the college course. If we plead, we plead against the tendencies to accept a larger salary, especially if the position has no future.

Professor Magruder: Mr. Downton must remember that some special apprenticeships start the young man with a salary of seventy-five dollars a month. I believe that the college professor can be of much service by advising his students not to accept positions which are of the nature of gold bricks.

Mr. Downton: We have no great criticism to make against the courses as they exist, but we should like to impress upon the professor who recommends men to use care in sending us men who will take full advantage of the opportunities of our apprenticeship course.

EDUCATION FOR INDUSTRIAL WORKERS.

BY ARTHUR D. DEAN,

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We already have industrial schools, manual training high schools and technical colleges. That they have successfully trained foremen, superintendents and managers is not to be questioned. Present economic conditions demand another type of school which will have the same general motive except that the specific aim must be to benefit the industries through training skilled workmen. We may have any number of higher technical schools graduating well-trained engineers who will become the commanding generals and the chiefs-of-staff of our industrial system, but unless we pay corresponding attention to the proper technical training of our captains and first sergeants this same industrial system will fail of its full development. In brief this has been the point of view of those who have advocated the technical high school and the manual training high school. I am not concerned at this time with the educational problems of what is the proper training for the commanding officers of the industrial army but desire rather to point out an educational scheme for the rank and file; for any army must have well-trained ranks of privates and corporals, if the efforts of its commissioned officers are to be most efficiently carried out.

It is time to take a very forward step in the educational world, a time to inaugurate a departure in our educational scheme by establishing trade schools which will keep pace with the growth of the industrial system and supply its needs. The trade school is frankly vocational. It is intended to fit a man to earn a living in some specific way. It is an educational system which teaches the science and art of a trade in the way demanded by the industry and which keeps pace with its growth and development. It has for its controlling motive the turning out of one product, a skilled workman capable of advancing the industrial life of the community.

In discussing the subject of trade schools, nearly every advocate lays emphasis on the need and neglects to analyze carefully the methods which might be pursued to make them a part of our educational and industrial system. I shall not say as much about the *why* we should have trade schools as about the *how* we are to go about it to get them. There are many discussions at the present time and many influences at work which distort the true purpose of these schools. In brief, the arguments for them consist of, first, the need for skilled workmen; second, the inadequacy of the apprenticeship system; third, that we should imitate Germany's scheme of industrial schools.

The industrial need of trade schools has never been so great as now. The prevalent national prosperity has been the means of giving work to all able-bodied men who want it, regardless of whether they have been trained for special service or not. At the pres-

ent time we are unable to make that careful selection of labor which is essential to stable prosperity, for periods of prosperity offer smaller lee-way in the selection of labor than times of depression. The present lack of skilled labor due to prosperity has done more than any other agency to emphasize the need of trade schools.

The ever-growing rapid industrial changes require a modification of the processes of manufacture. This means a need for the kind of labor which has the requisite *adaptability* to adjust itself to new industrial conditions. This is essentially an age of machines, a time when hand processes are being discarded for machine processes. There is an ever-increasing use for a cheap grade of labor to run the automatic machines and accompanying this is a need for skilled mechanics to build these machines. A high grade of labor is a prime requisite for employing a cheap grade of labor in manufacturing articles of commercial necessity at a low cost of production. It is the unanimous opinion of machine-tool manufacturers that a certain number of all-round workmen are needed even where extensive specialization is employed and a few men at least must receive a systematic mechanical training which will make them capable of resisting the deadening effects of specialization.

The average apprenticeship system is inadequate for two reasons; first, the limitation of the number of apprentices by the trade unions; and second, a laxity on the part of manufacturers in giving thought to systematic training for their young workers. The

sole basis for the number of apprentices a manufacturer ought to employ should depend upon his ability to handle them as a part of his factory system without injuring the grade of his finished product. Manufacturers must give some thought to the training of their apprentices. If they do not have skilled men ten years hence, they will simply reap what they have sown.

Another need of trade schools which might be mentioned is the moral need. The industrial worker needs social recognition through educational activities of a special sort that his work is worth while. The general lack of trade education practically points out to industrial workers that they are engaged in a life's work which is not worthy of being dignified by education. It assumes that while it is necessary to train the man who designs a machine it is not essential that the man who makes it should receive special training. We talk a good deal about the "dignity of labor" but we must impress upon the worker through special training that there is after all a use for technique, skill, and an industrial conscience; that he has something after all to sell which entitles him to be an efficient industrial unit because he has gained this right through experience in his chosen trade.

There are several movements now on foot for the establishment of trade schools. One is that initiated by the teacher. He states that boys do not remain in school long enough and that some scheme of education must be devised whereby they will remain after the legal limit imposed by the compulsory-

attendance laws. He claims that they leave school at fourteen and waste two years in drifting along lines of work which do not give them an economic hold on the industrial life. I regret that the teacher advocates for these boys only manual training, whereas I believe that he should propose trade training for these boys. I regret that he impresses upon the public that the public school does not and will not teach a trade. He states that the shopwork in the schools is to teach only the mechanical principles underlying the trades and these merely for their educational value. Only 6 per cent. of 2500 graduates of our manual training high schools have become mechanics.

This result may justify the existence of the manual training high school, but at the same time it strongly points to the need of another type of school which will teach the youth of our land to become *first-class mechanics*. I believe it is the proper function of the school official to advocate a type of school which in its purpose frankly and openly states that it can and will fit a boy for a good workman at a chosen trade. Our head-workers must come from the ranks, if we are to get the best work out of these workers. To eliminate the chances for promotion which give a worthy purpose for ambition and foresight by taking into our industrial system foremen and superintendents outside of the ranks is to crush the workers and eventually kill the industrial system. The phrase "room at the top" must not lose its significance through closing the entering door by taking into the industrial system too many men trained outside its industrial ranks.

Among the objections to trade schools is that they cannot teach a trade and that the only place to learn a trade is in the shop. I believe that this statement is unfair as the few trade schools which exist have demonstrated that a trade can be taught as a part of an educational system and the graduates have gone into the shops and "made good." I do not claim that they can learn all that concerns a trade in any school. Neither do they learn all there is to a trade in a shop. It is a self-evident truth that no man learns all that there is to a trade or profession no matter where he receives his training or how long he practices it. It seems to me that definite organized instruction in the use of various tools and machines in a trade school will turn out workers superior to those who like Topsy simply "grew up" in those manufacturing establishments which take no pains to give systematic instruction to their young workers.

Let us consider some of the reasons why the trade school can render better service than the average shop in developing skilled mechanics.

1. The school can help make a profitable workman in a shorter time by giving him under instruction legitimate shop-practice in the work of the trade. Definite practice in the work of the trade from the very beginning in a school is a far different proposition from sweeping, piling castings, running errands for several weeks or months in the shop.

2. The school can give a series of graded lessons, general and fundamental, upon which other work may be based and future efficiency more certainly developed. The lack of sequence in the ordinary shop

work becomes for the average boy merely routine work and he flounders around.

3. The school can give the opportunity to do a task over and over again until it is done right, the opportunity to study each problem closely and deliberately. In a shop there is little chance to try again. The work must be thrown away. A "call down" in the shop can never take the place of *definite instruction* in a school.

4. The school can give a broader, more intelligent idea of the relation of the parts to the whole. The beginner learns the dependence of one part on another. The tendency to keep a cheap grade of labor doing one thing may make a tolerably good operator, but if we expect our bright boys to respond to an unusual problem they must have a chance to practice all the usual operations of production.

5. In the school, the instruction is direct and personal, given by one who is selected not only because of his superior qualities as a workman but because of his ability to teach. The instruction in the average shop is haphazard and accidental given by a foreman who is already harrassed by a multiplicity of details.

6. The school comes nearer to taking the place of the shop as it approaches the commercial standards of the shop. The incentive of the commercial demands of the shop will emphasize the value of time. A clear conception of how a piece of work should be done is necessary at the outset to avoid a waste of time.

To hope that municipal authorities will take the

initiative with reference to trade schools is expecting too much, for unfortunately some politicians only see the popular mind of the people through the eye of the labor leader and most labor leaders are opposed to trade schools. Also there will be difficulty in disposing of the finished products of these schools if they are under municipal auspices. In order that the work may be of a thorough, practical sort it must illustrate actual trade processes. The parts must be assembled into a complete machine in order to illustrate all the commercial processes. When these machines are complete they must be disposed of in the market. If we bear in mind the past experience of some state reform schools which have attempted to dispose of their products, and have been prevented from so doing, and finally have given up their industrial and trade work, one can readily see that the disposition of the finished product becomes a real and serious problem.

We need a few trade schools to serve as practical illustrations of what they are capable of doing. We need schools which can practically answer the statements that a trade can be learned in a school and that trade schools are a benefit to the working man. We must show what a trade-school is like. I believe that these schools must pass through the same experience which was undergone when cooking, manual training and kindergartens were established. They were introduced at first under private auspices and demonstrated their value before they were accepted by the mass of the people. I am a believer in the theory that *private initiative creates public enter-*

prise, and that no better service can be done than to educate through private trade schools the public conscience to the point where it will see some practical examples of their value. In its preliminary development the trade school movement will go forward only as a private enterprise. These schools must have the interest of the manufacturer. They must have his suggestions. He has been the largest factor in industrial development. He recognizes that the trade school can substitute definite systematic instruction for the haphazard, uneconomic training in those shops where no special effort is made to train industrial workers. Practical men know that special education for a trade, accompanied by training in mechanics, mathematics, science and precepts of clean living, will serve as a basis for stable equilibrium in the industrial world now so often upset through industrial strife.

The two points to keep in mind in all discussions of trade schools are first, the American boy who is desirous of an opportunity to learn a trade; and second, the establishment of a school which will give him such training.

Naturally you want to know what sort of a definite proposition I can present to this Society and so I offer the following suggested outline for a trade school preparing students for the machine trades as an illustration.

In regard to its nomenclature it must be called a trade school. It must not be called an industrial school or a preparatory school for the trades. Its name should not cover up the character of the work

which it intends to do. It should in its very name define the nature of its proposed work. There should be no hesitation in calling it just what it is.

Naturally the question arises, what class of students will be taken into the school. The students should be recruited from any class wherein an individual feels that a knowledge of a trade will be of value to him. In all probability the great majority of recruits would come from the rank and file of workers and the whole atmosphere of the school should be such as to make them feel that its work was for their benefit. It must be a school which will instil into the minds of the boys the idea that they are going to become workmen and good workmen, and that if they are good workmen they may become superintendents and foremen. It must avoid start-them out with the idea that they are to be superintendents and foremen immediately upon graduation. It should awaken in them a desire to be *good workmen*.

The school should run eleven months in the year, fifty hours a week, or in other words should imitate the hours and holidays of the factory. The hours and working days being practically the same as those in the shops would teach the students habits of regularity which they must learn in actual employment. I would suggest that the month of August be taken as a shut-down period. This does not imply a vacation but rather an opportunity for making necessary repairs for next year's work. Boys in the school who need money should be hired to do this repair work.

The school should be open both day and evening,

although whether such a school could be run successfully for two kinds of work depends entirely upon its organization. To run it successfully both day and evening would require practically a double force of instructors. This, however, is a detail in organization. The day class should be composed of boys who have been secured with a great deal of care as regards mental and physical fitness for the future work which they are to do. They should be taken into the school for a trial period of three months. They should be set at work the very first thing on a job which will test their ability to do mechanical work. Sweeping floors may demonstrate a boy's ability to sweep, but it will not point out to the school managers his ability to make a good mechanic.

The school should be open evenings for young men who wish to advance themselves in their trade. Few, however, will care to spend their evenings in the same class of work in which they are engaged during the day. This department will reach fellows of a different calibre, whose qualities of mind and mechanical ability cannot be judged by written entrance examinations. Their fitness to enter the school can be determined by a practical examination in one or two pieces of shop work and a five-minute interview in order to "size up" their characteristics.

The "core" of instruction should be shop practice and the book learning which fits in with the machine trades. This means that the major subject will be machine-shop practice. It also means that there must be some mechanical drawing, pattern making and molding. The course of instruction will not be

complete unless there is academic work in English, business forms, mechanics' arithmetic and physical science. The instruction in all this work must be carried on expressly to meet the needs of the machine trades. It must not be taken from elaborate text-books in general arithmetic, general English, etc., but rather from courses which have been carefully worked out by practical men who know what topics are of vital importance to a boy who is to be engaged in a machine trade. Incidentally there should be inculcated in the minds of the students a power to reason on social and economic problems along lines which will give them that proper point of view so necessary in these days of the relation of their individual responsibility and life's responsibility. To so teach boys that they may earn good wages at a trade, and at the same time neglect to give them that training which will enable them to live wisely while earning that money, is a false position for any school to take. However, I should not have social and economic work incorporated as a set course. It is rather a point to be considered as entering into all the instruction.

There should be a tuition fee both for the day and evening work. It is the experience of most of us, not only in school work but in all concerns of life, that what we pay for we value, and that what we get free is not always appreciated. Provision should be made for those applicants who cannot pay the necessary fee by some scheme of scholarship fund, provided for by those patrons of the school who are interested enough in boys to take care of them financially while in school. After the boy has gone to work,

the loan can be returned to the scholarship fund or to the one who loaned the money.

In order that the trade school shall command respect it must do work in a commercial manner which is another way of saying that it must do commercial work and if it does this it will be possible to pay wages to the boys. The boys should be paid wages after the trial period and these wages should be increased regularly according to the ability which each boy shows. It may seem strange to propose a tuition fee and at the same time return it in the form of wages. The tuition fee is a guarantee of business earnestness of the boy, his parent, guardian or patron. Paying boys a small wage on a rising scale is done simply because we must recognize the moral value which accrues to a young man when he finds that his advancement in his trade is appreciated. It puts a practical aspect on the school's methods and affords immense satisfaction to the young man when he receives definite compensation for his labor through an advancing scale of wages due to increased efficiency.

There is no one who ought to be more qualified to teach these young mechanics than a competent, practical man. That there would be some difficulty in obtaining such a teacher I will acknowledge. It in itself forms an argument for the need of trade schools when we are obliged to acknowledge that not even a few men can be found who are competent to be teachers in a trade school. A successful instructor for a school of this character must be a man of exceptional ability. He not only would be required to know his trade fully, but would have to combine with

that knowledge ability as a teacher, tact and diplomacy, which perhaps would fit him for positions paying far higher salaries than would be given to the instructor of a trade school. At all events, the instructors will determine the success or failure of these schools.

As the school is to be a trade school and is to teach machine trades, it must for the very sake of this aim make the work of practical character, or, in other words, must make the work of commercial character, of the sort which will take a boy into real commercial life. This involves a turning out of products which will satisfy in points of accuracy and skill the demands of the industry. It means the doing of things according to commercial processes. It means that the time and materials consumed must be considered. In fact the school must imitate schemes of "works management" in order that the graduate may immediately fit into the economics of shop life. Throughout all the work, the students must be taught the economy of material, tool room methods, shop kinks and cost accounts. Frequent excursions should be made to the neighboring manufacturing establishments.

In order that the school may best illustrate commercial methods, it should make things to sell. It is understood that these things are not made merely to sell for the sake of financial return but to completely illustrate the commercial requirements of a trade. The school can do the following lines of work.

1. The making of some regular line of machinery like a bench grinder, speed lathe, bench lathe, arbor

press, etc., which will illustrate to the boys how jigs and fixtures can be used in modern manufacture where a number of machines are turned out at one time. This procedure should serve to keep the shops going at all times regardless of the other lines of order work which might be on hand.

2. The school should also take repair work for small concerns. It can buy up second hand machinery and repair it. This sort of work gives a splendid opportunity to turn out all-round workmen. It will serve to illustrate re-babbitting, re-surfacing, making of patterns from broken parts, making of castings directly from the iron form, etc.

3. Doing order work in the making of jigs and fixtures for various manufacturing concerns. This special order work can be done by older and brighter boys who understand the reading of drawings and the laying out of the work. It will give them an opportunity to use their ingenuity in discriminating between that work on the jig which must be done very accurately and that which can be slighted without damage to the commercial efficiency of the jig. It will teach the boys how to figure on the cost of jobs, etc.

And finally, the making of patterns and castings for special orders of outside firms.

There is not a city of any size which has the machine trade industries which cannot have such a school provided there are enough resident manufacturers who have an interest in the American boy as well as an interest in the future of American industry, and provided these manufacturers and public-spirited

men will put their hands down into their jeans and give the money necessary to start the school.

I suppose the school can never be completely self-supporting although some men who think they know what they are talking about (and two of them have tried it) say that it can be made self-supporting. Personally I think it would be well to allow a little financial lee-way. It is not necessary to wait until these interested men can gather up money enough for a fine building. All that is necessary is to lease for a term of years a building suited to the purpose. There are manufacturers of iron working machinery in the country who will be glad to contribute liberally to the equipment. There is enough second-hand machinery in various scrap heaps which can be repaired to use as part of the shop equipment. It is not necessary to have a power plant in the building and thus the cost of an expensive portion of ordinary school equipment can be saved. Electric power will be sufficient for practical purposes the first few years.

I have estimated that a yearly expense of $22,000 will give instruction to 200 boys in the day school and 275 boys in the night school. This sum includes administrative and teaching force, rent, heat and light.

In conclusion, you will note that in this paper I have concerned myself with the importance of training the ranks of labor through systematic instruction for purposes both economic and industrial. I have also endeavored to present a definite plan making for this end. Surely the element of efficient labor entering into the cost of production is as worthy of serious attention as are the two other elements of material and equipment.

COURSES IN INDUSTRIAL ENGINEERING.

BY HUGO DIEMER,
Consulting Engineer.

From a purely technical point of view, the work of the mechanical engineer is limited to the designing and construction of efficient machinery. From the point of view of world-economy his work includes the making of machinery in such a manner that the highest quality of output can be built cheaply enough to put it into the widest possible use, and the processes of designing, manufacturing and testing should all be carried on in such a manner as to result in the greatest possible economy and profit to all of the human factors connected with the enterprise, namely the designers, the workmen in the shop, the stockholders in the business, and the people who buy the product.

Any manufactured commodity before being put on the market must pass through the three distinct processes of designing, making and testing. Hitherto courses for educating mechanical engineers have concerned themselves primarily with the processes of designing and testing. The existing courses are admirably adapted to fit men for these processes. Our manufacturing industries have now passed beyond the pioneer stage, and while there is a continued proportional annual increased demand for men equipped to design and to test, there is a much greater demand for men equipped to deal successfully with the processes of making. The relative economic value of

these three processes may be illustrated by taking as an example the work of a company manufacturing mining locomotives. The pay-roll of the designing department in a well-known company engaged in this business was $20,000 per annum; that of its testing department was $5,000 per annum. In the making of the article, exclusive of the aforementioned departments, there was spent in labor alone $400,000 per annum. The amount of money spent in making the machinery was twenty times as great as the amount expended in designing, and eighty times as great as the amount spent in testing. There were five hundred men employed in the making, as against twenty-five men engaged in the designing and five men engaged in the testing. Out of the five hundred men employed in the making there were seventy-five engaged in supervisional and clerical work connected with the production department, and in no way connected with the commercial accounts, commercial correspondence or sales. These figures are given as a typical illustration of the relative number of people affected and the relative amounts of money involved in production as compared with designing and testing. We are unconsciously limiting the field of the graduate engineer by imaginary barrier lines when we do not prepare him for the productive processes.

Directly below the managing officials of a manufacturing plant ranks the works' manager, who is also frequently designated by the title of chief engineer or superintendent. He needs to be a man with practical experience, a production expert with knowledge of executive matters. It frequently happens

that in the absence of his superiors he is called upon to manage the establishment, directing the cooperation of the departments, ruling on emergency questions that arise and involve the integrity and policy of the company; a technical man, he yet has a broad outlook on the affairs of the concern, which enables him to direct the workings of the whole plant.

Such a man is a type of the highest development of the mechanical engineer. Considering the great number of school-trained technical men in modern industry, it would seem that eligible candidates for this position would be numerous. On the contrary, the great majority of men occupying these executive positions are not at present school-trained technical men. Technical graduates becoming engrossed in one specialized branch of their profession, fail to realize its relation to other departments of production, pushing to the extreme ideas of their own, which wise management would temper to fit the needs of other departments.

I think it is a conservative estimate to say that not twenty-five per cent. of the graduates of engineering colleges achieve the degree of success which they might. One difficulty is that while at school they have prejudices unconsciously instilled into them which prevent their entering production departments in manufacturing. Some of the students, to be sure, go to the other extreme and take work as actual mechanics. From the standpoint of the experience of a practical shop manager, it would be far more advantageous to them to take a position as time taker, shop order tracer or stock clerk. In the stock department they would gain familiarity with

every kind of material and every completed part. They could use this opportunity to learn the best sources for obtaining materials, the prevailing range of prices and the amounts usually carried in stock. They could study the complete or partly finished product, which fills the shelves. The shop order tracer can see in process of manufacture the various articles put out by the plant. A young man set to work following a machine order through the shop will soon learn all the processes through which it passes. In watching this transformation from raw material to finished product, he can get a general view of all the operations that is hidden from the draftsman or designer specializing in only one process.

In a position as time taker he will have not only the opportunity to study processes and to cultivate the difficult art of handling men, but he will be able to study the time consumed by different men on similar work, and by the same men on different work, for his duties will be to record the work done by a certain group, noting the time when each of them begins an operation and the time when he completes it. He will have an opportunity to notice the conduct and the methods of those men who prove to be most efficient, and to study the systems of discipline that bring the best results. These are the possible means by which a technical graduate can gain an insight into factory operation and management, which he can gain in no other way in so short a time. If he is ambitious to reach the top, such work will not hold him very long. An opening will come in some

one of the departments and he will be chosen to fill it, and his special training, supplemented by his school training, will be of great value to him.

Three associated lines of work offer avenues of approach to the chief executive position in a manufacturing establishment, through any one of which he may rise if he perfects himself in the line of work he has chosen and learns the essential principles of the allied departments. These three branches are the designing department, the systematizing department and the shops. In most establishments the head of any one of these branches is eligible to promotion to the position of works manager.

The difficulty with men who have begun work as draftsmen is that they do not sufficiently study productive processes. They need continually to guard against the dangers which all designers face: the temptation to push refinement and improvement of designs to such an extent that the processes of manufacture are hindered, and in many cases involving useless expense and no practical advantage. The greatest danger to the designer is his tendency towards the impracticable in his zest for improvement. I have known machine construction shops where it was necessary to pass a strict rule that no change in the drawings for a machine could be made after the materials were ordered, so prone were the designers to offer suggestions for changes after the machines were partly constructed. After perfecting himself in his own work, the designer needs to study the other departments of the establishment. He must learn what the systematizer and the shop superintendent

aim to secure—economy and practicability; hence his school education should be such as will lead him to a study of costs of production, labor, power and material. He should learn to cooperate in keeping these cost figures to the minimum. He needs to study the peculiar needs of his plant and the uses of its output.

Instead of allowing themselves to be prejudiced against entering the systematizing department of factories, technical students should be encouraged to enter this branch of work. In it they will have access to the working systems of all departments; they should use this opportunity to learn the details of operation as well as the outline. They will have opportunity to learn not only what are the component elements of the cost of a part, but the exact figures of its cost. They will be able to study not only how a machine may be followed up in its course through the shop, but how fast it is practicable to push it. They must be able to learn what is the most advantageous manufacturing quantity of every item, so as to secure uniformity of manufacture. They will be able to learn how long each step ought to take under the most favorable working conditions; they will be able to know how to tell at any time the exact condition of every part involved in the manufacturing processes. In short, they will learn not only how to plan, but how to execute. This requires the cultivation of a knowledge of men, as well as a knowledge of systems.

The systematizing department probably makes more versatile executives than any other line of work in the manufacturing business. A knowledge of pro-

duction systems, no matter whether secured in a furniture factory or an automobile shop can be applied, in a large part, to other lines of manufacture for the fundamental principles are alike in all. I have known men who were trained in electrical manufacturing plants, who passed to gas engine works, harvester plants and automobile companies, applying to all of these diversified lines the experiences which they had gained in each of the others.

Positions as works' manager are waiting for men who show their ability to handle the problems that arise in any part of the plant—who are able to deal with rush orders, labor situations and hard times, or excessive prosperity. Such men need to possess the qualities of adaptability, breadth of experience, and progressiveness.

A study of the lives of the heads of our greatest industrial corporations reveals the fact that each one of them had to acquire a thorough knowledge of conditions as to annual supply and requirements of raw material and finished parts, as to detailed cost analyzed into time units as well as into dollars and cents. It was necessary to acquire this knowledge in detail and then to apply it to a comprehensive dealing with the whole situation at any time.

During the past nineteen years I have been engaged primarily in systematizing and organizing manufacturing establishments, and each year has brought home to me, emphatically, the great opportunities that are open to technically educated men in this field. During the last year I have made a special effort to secure technical graduates to fill minor

positions in this line of work, in order to develop them to fill staff positions in the productive side of shop management. My first question to applicants usually is: "What department did you have in mind as the one in which you wished employment?" I seldom fail to get the answer: "The designing or testing department." On further conversation I find that very few applicants have acquired any broad outlook of manufacturing in its relation to human affairs. It is difficult for a technical graduate to enter the productive side of manufacturing, on account of a prejudice against him because of his education; these prejudices are held both by clerks who have never had anything but a grammar school education and by shop foremen, who have had about the same schooling and have risen through the ranks as mechanics. When I tell a foreman in the shop that a young man I am starting is a graduate of such-and-such an engineering school or university, the usual answer I receive is: "That settles it—he's no good." As a matter of fact, only about one of four who start remain; some of them leaving of their own accord—others not being retained.

The chief qualification requisite in the candidates that remain is thoroughness in every detail. The lack of this qualification is the principal adverse criticism I have to make of the ordinary run of engineering graduates. It must be remembered that among the rank and file of mechanics and clerks there has been going on constantly a process of elimination of those who are trifling and incapable until those who remain in the ranks as employes are, of neces-

sity, such as have some degree of thoroughness. These are, therefore, the more quick to notice any tendency towards superficiality on the part of engineering graduates put to work among them. I believe that engineering graduates could be made to be a great deal more thorough in their work if a demand were made on teachers of engineering subjects that they possess, in addition to thoroughness in the subject that they are teaching, also a knowledge of pedagogic methods. My own experience has been that I learned less from some instructors who were really brilliant men and masters of their specialties than I did from others who held minor positions, but who were thorough teachers.

Several years ago I presented to this Society a paper on "Education for Factory Management"* which elicited considerable discussion. The majority of the members taking part in the discussion agreed with the general proposition that the teaching fraternity needs to take cognizance of the fact that engineering graduates will be looked to more and more as the men who are to be the managers and executives of great industrial enterprises. Quite a number of members claimed that it was not feasible to drop anything out of existing schedules in order to substitute any additional courses. Should the members of this Society agree that this is still the case, I claim that it is certainly worth while for an engineering student to add a fifth year to his university career if by so doing he increases his chances for eligibility to positions in which he can be of more valuable service to the community at large.

* PROCEEDINGS, Vol. XI, p. 151.

It should be borne in mind, however, that I advocated not only the teaching of additional topics, sufficient in number to make the course cover five years, instead of four, but that I advocated also the modification of existing courses so as to impress upon the students the adaptability of these courses to actual engineering and manufacturing practice. By this I did not, by any manner of means, intend to convey the idea that university students are to "play at business," after the manner of cheap, quack business colleges. Those members of the engineering teaching fraternity who have had actual manufacturing experience in positions of responsibility will know exactly what I mean. Those who have not had such experience will not be quite so able to understand me, and will be more apt to misinterpret my motives. I mean that machine designing, for instance, should be taught so that the machine designed can be actually built in a present-day commercial factory. I mean that if a student has designed a boiler as part of his course, he should be able after his graduation to accept employment in a position where he could be depended upon to build boilers, and do any other kind of plate metal work of the highest quality at the lowest cost at which the articles can be produced. I recommend that as part of the work in machine designing, the student be required to prepare a complete bill of material of all parts entering into the article designed. For instance, if he were designing a dynamo, he should specify the exact kind of insulating material, and the quantity of same required for insulating the armature slots, and not make the general statement

"insulation as required." He should be taught to specify commercial sizes of bolts, screws and threads. He should also have impressed upon him the fact that it is oftentimes cheaper to use the same finished part for several different purposes. He should learn to avoid multiplicity of drawings, patterns and tools, and in every way possible to harmonize design with economical commercial practice.

In connection with the shopwork it is my opinion that the purely manual features of shopwork belong altogether in the secondary schools; that if shopwork is taught at all in schools of university grade, it should be taught in such a manner that the student becomes thoroughly conversant with the quickest and cheapest way of construction and manufacturing. This should be the aim, rather than any attempt to make him an adept with his hands. I suggested in my previous paper that where shopwork was employed, the upper classmen be employed as foremen. By this I meant, not that they should teach the others how to do the work, but that they were to make a study with stop-watches and cut-meters of the times required to do operations—that they specify the sequence in which various operations are to be done and calculate total cost of time required to accomplish machine work and construction work.

Physics and mathematics are other branches of study which should be dwelt upon at greater length with regard to problems connected with manufacturing practice.

So far I have advocated nothing which requires the insertion of any additional subjects into the present

four years' courses. I am simply advocating the teaching of topics in a different manner. The manner of teaching which I advocate requires that the instructors themselves be not only capable men from the standpoint of theory, but that they also be practitioners themselves or at least familiar with commercial practice. It will be noted that I have not advocated the spending of any additional time on what may be called purely mechanical training.

I would, however, advocate the spending of additional time on such subjects as will make a broader man of the student. The principles of sound economics demand that we permit only such men to become industrial managers as are qualified; the demand certainly exists and it is only a question of time when it will be properly and intelligently met.

In order to make broader men of the students I would add additional subjects to the regular four years' mechanical engineering schedule as now taught, such additional subjects, together with the regular present four years' schedule, constituting a five years' course, which may be known as the course in industrial engineering, such a course being intended primarily to develop men for the management of industrial enterprises. The additional subjects which I would add are as follows: Economics, sociology, logic, psychology, accounting, statistics, and modern business systems.

I do not wish to be misunderstood as claiming that we can by any system of education prepare young men so that immediately after graduation from some kind of a college or university course they can be

fully fledged managers or production engineers. The work of industrial management is of such a nature that it requires not only thorough preparation, but the stability of age and practical experience, which should cover not only a period of from five to ten years, but varied fields of work.

The course in industrial engineering, however, can develop an aptitude as well as a desire to fill certain minor staff positions in the management of industrial enterprises, so that a technical graduate may, after serving several years in the ranks, either in the mechanical or systematizing departments of a manufacturing establishment, be able and willing to assume the duties of head of a department. I claim that we should have, and I believe that we will have, an increasing number of technical graduates filling these minor positions, and thus working up to the positions to which their education and experience will then entitle them, namely, positions as superintendents and managers.

I believe that strictness in admission requirements and the maintenance of thoroughness throughout the course, as outlined by President Atkinson, of the Polytechnic Institute of Brooklyn, should not be confined to that institution alone. In order to maintain a general respect for graduates from technical universities, we must be more rigid in our requirements from the students. Less in quantity and more in quality should be our watchword. One difficulty in the way of this is the present-day method of securing appropriations for educational institutions. A university president is sometimes forced to become

an advertising agent and a lobbyist, and to shape his institution so as to suit the tastes of legislators rather than the best interests of the community. An appeal for further appropriations often requires to be backed by a showing of increased attendance, and a detailed departmental budget is apt to be allotted by a board of regents or trustees on the same basis of attendance. The result is that deans of engineering schools, without intending to do so at all, sometimes become more lax in their requirements, in order that the number of engineering students may show up favorably enough to draw the needed appropriations. The standards which President Atkinson specifies for the Polytechnic Institute of Brooklyn are attainable in any of our state institutions. The fact that an engineering school is a state institution should by no manner of means be considered a reason for permitting an incompetent student to secure a degree.

SOME CLASSROOM EXPERIMENTS IN MECHANICS.

BY JAMES E. BOYD,
Professor of Mechanics, Ohio State University.

In teaching mechanics at the Ohio State University we give a limited number of classroom demonstrations to illustrate the fundamental conceptions of the subject. We aim to have these experiments on a sufficiently large scale to be clear to all the members of the class. The experiments are usually quantitative. The actual readings are generally taken by some of the students, and they are at once worked out on the blackboard, sometimes by the instructor or some one member of the class, more frequently by the entire class. The method used depends, of course, upon the nature of the problem and the state of the students' knowledge of it. As a general proposition, each student profits most by what he himself does. At the same time, it is not economical to permit a class of beginners to flounder around after something which only a few can reach.

The experiments which I am about to describe are some of those which we used during the past year—apparently with profit.

I make no apology for their extremely elementary nature, for it is impossible to make work of a physical character too elementary for the average student; and I am convinced that, if the fundamental conceptions are really mastered, only a little common sense

and a working knowledge of mathematics are needed to solve the complex problems.

Figs. 1 and 2 represent a cantilever beam made of 2 x 6-inch pine. A chain *A* takes the tension. In Fig. 1 the compression is taken by a light cylinder *B*.

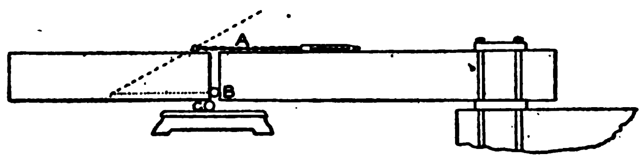

FIG. 1.

The distance between the chain and the cylinder is measured and multiplied by the tension in the chain as given by a spring balance to get the resisting moment. The weight and location of the center of gravity of the portion to the left of the section being determined, the resisting moment and the external moment may be compared.

There remains the vertical shear, usually a rather vague idea to the beginner. To measure this we place a cylinder *C* under the right end of the free portion and support this cylinder by a platform scale (shown reduced) reading to one fourth ounce. The reading of the scale is found to be the weight of the portion of the beam to the left of the section, as we already know deductively.

We now lift the right end of the chain till we reach the position shown by the broken line in Fig. 1. The weight on the scale becomes zero and the cylinder *C* may be removed. If we extend a line parallel to the chain, we find that it intersects the horizontal line through the cylinder at a point directly below the

center of gravity of the left hand portion of the beam —the condition of equilibrium for three forces.

Fig. 2 shows the same thing with the tension horizontal and the compression taken by a square block *D* held at the right angle. Or both block and chain

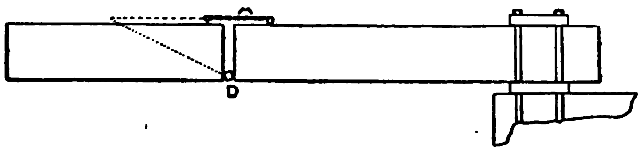

Fig. 2.

may be placed at an angle with the horizontal, illustrating the fact that shear may be regarded as made up of tension and compression. Again the block *D* may be put in with its faces parallel to the section. If the surfaces are smooth, it is probable that the friction will not be equal to the shear when the block is near the bottom. It may then be raised so as to increase the normal pressure, and equilibrium secured.

In Fig. 3 we have a simple beam. The compression is now at the top and the tension at the bottom.

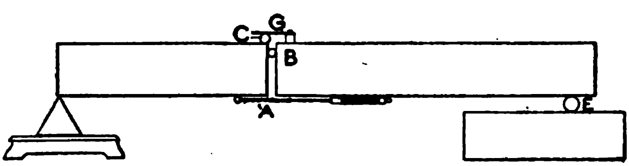

Fig. 3.

The shear is taken by the cylinder *C*, which is placed between the left portion of the beam and the projection *G* attached to the right portion. This shear may be up or down, depending upon the position of the

supports and the loads. If, in Fig. 3, we move the right support *E* toward the left, we find a position of zero shear. We may now determine the left reaction by means of our platform scale and we find that it is equal to the weight of that portion of the beam between the left support and the section.

In Fig. 4 we have placed a block *H* between the chain and the right hand portion of the beam and

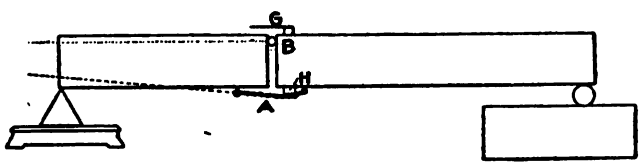

FIG. 4.

removed the cylinder *C*. The shear is now taken by the vertical component of the tension. If we extend a line parallel to the chain and a horizontal line through the compression cylinder *B*, we find that these lines intersect to the left of the left support. We now measure the end reaction, and knowing the weight and the position of the center of gravity of that portion of the beam to the left of the section, we calculate the position of the resultant of these two oppositely directed vertical forces. We find that this resultant passes through the intersection above mentioned—the condition of equilibrium for four forces.

For the elastic curve and deflection of simple beams and cantilevers, it is easy to devise experiments adapted to the lecture table. For instance, as a cantilever, we use a 2 x 2-inch yellow pine, ten feet in length, which is securely fastened at one end to a pair of 4 x 6-inch beams. As the end cannot be made absolutely "fixed," we attach a long light pointer to the

beam at the clamps and use this to determine the change in slope of the tangent at the "fixed" end. A better way perhaps would be to have the beam extend over a support and hold down one end by a screw. When a load is applied at the free end, the screw may be adjusted to bring the tangent at the support back to its original position. With such a cantilever it is easy to measure the slope and deflection at various points and compare with theory.

Fig. 5 shows another interesting case, that of a beam fixed at one and and supported at the other.

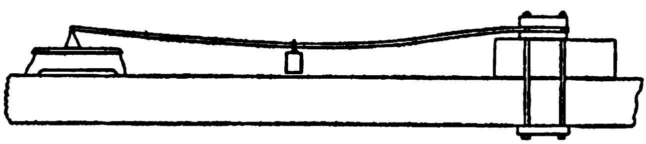

FIG. 5.

For this we used a four-foot maple rule securely clamped as shown. The change in slope at the fixed end is nearly negligible with the light loads used. The other end is supported by a knife edge resting on our platform scale. When a load is placed on the beam there is an increase in this reaction, which we measure and compare with theory. For instance, with the load in the middle of the span the end reaction should be five sixteenths of the load. When we placed a five-pound weight at the middle of this we found an increase in the reaction of 25¼ to 25½ ounces. With the weight at other points, such as three tenths of the span from the left end, the reactions agreed with theory to within two per cent., and were always too large, as we should expect from a beam not absolutely fixed.

One of the difficulties in teaching mechanics is to find quantitative demonstrations of the second law of motion. The accelerating elevator, street car, baseball or boat give qualitative illustrations which are useful but not sufficient. The Atwood machine will do for the laboratory, but for the classroom the corrections for friction and the inertia of the pulley obscure the real aim of the experiment.

In Fig. 6 we have a method of getting around some of these difficulties. The pulley *A* of the Atwood machine is supported by a beam or frame *B* which rests on a knife edge *C*. This knife edge is adjusted in the frame so as to be in the vertical plane of the center of the descending cord *D*. The load on this cord has no effect on the equilibrium of the beam. Neither has the friction, which is an internal force with respect to the beam and pulley treated together as a free body. These statements may be proven to the class experimentally and serve to illustrate some propositions of statics which have been previously learned.

We now place a mass *G* on the left string *E* and a sufficient weight on *D* to keep the pulley from turning (or we may tie the string *D* to the frame), and adjust the weights at the end of the beam and the poise *W* until the beam is balanced. Now add to *D* a weight *F*, which is greater than *G*. We now find, as *G* is accelerating upward, that there is an increase in the force exerted by the string *E*, and the poise *W* must be moved to the right to balance the beam. A few trials with the same weights *G* and *F* will enable us to determine the position of equilibrium while

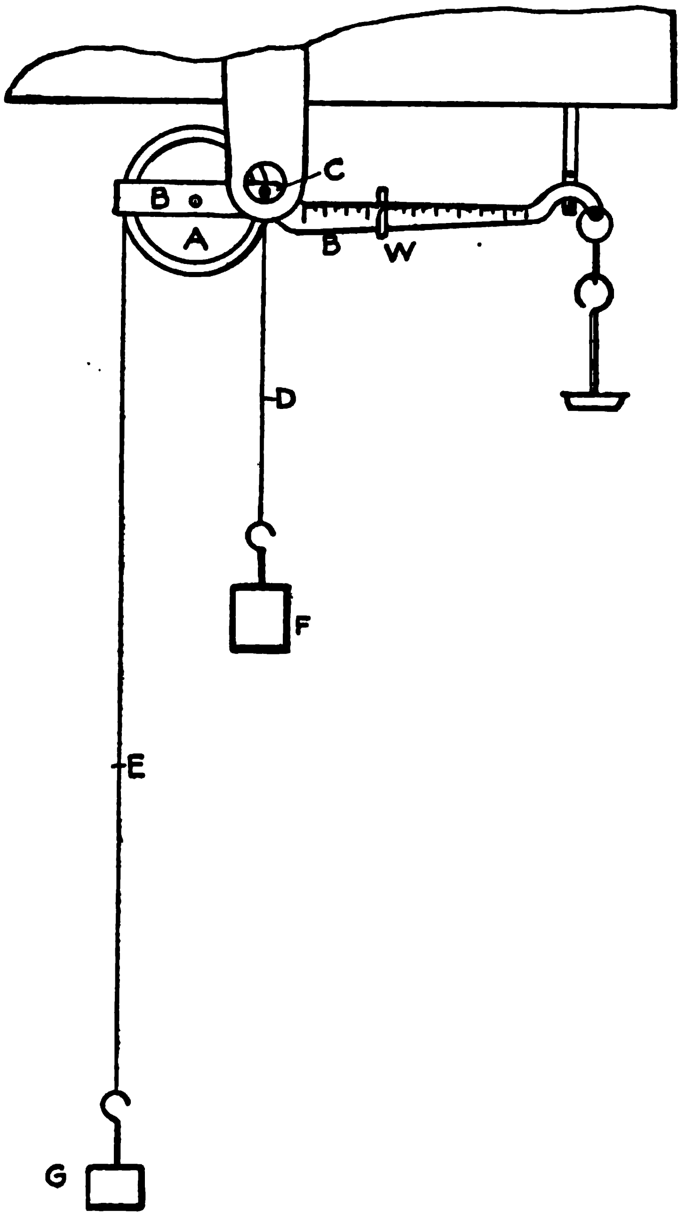

FIG. 6

the bodies are accelerating. The quantity measured by the movement of the poise is the force required to accelerate the body G (and the string E), together with one half the force required to accelerate the pulley A. The correction for friction and the force required to accelerate the descending mass F are entirely eliminated from these measurements.

There remains the force required to accelerate the pulley, which we must either measure or eliminate—preferably eliminate.

In the apparatus as we used it this year, two small pulleys were used instead of one large one. These

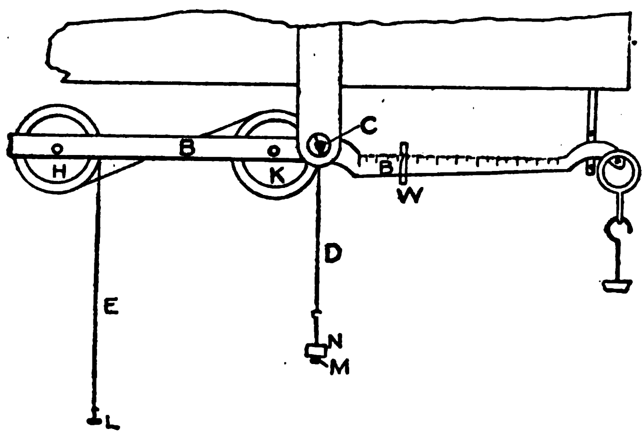

FIG. 7.

were placed sufficiently wide apart to give a large moment arm for the ascending mass with respect to the knife edge. When the pulleys are alike, it may be shown that the moment arm of the forces required to accelerate them is the radius of one pulley, a relatively small quantity. The moment of inertia of these pulleys being also small, we may neglect this term without any considerable error.

Fig. 7 shows a method of entirely eliminating this correction. It consists in the use of two pulleys exactly alike, but rotating in opposite directions. The left pulley *H* is placed a little oblique, so that the two parts of the string do not rub together, for while it makes no difference how much friction we have in this apparatus, the friction must be constant.

We may show experimentally that this does eliminate the inertia of the pulleys in so far as it effects the equilibrium of the beam *B*. Place a very small body *L* on the string *E* with a similar body *M* on the string *D*. Adjust the poise *W* till the beam is balanced. Now accelerate the pulleys by means of a larger mass *M* placed on the descending cord *D*. We find that the balance is not appreciably changed. Now change the string around *H* so as to make both pulleys rotate in the same direction. (It will probably be necessary to go entirely round *H* to prevent the string from slipping with a very light body *L*.) We find now that there is a considerable difference in the balance when the pulleys are accelerated.

If we replace the pulley of Fig. 6 by a drum, round which the string may be wound a number of times, we have the well-known method of determining moment of inertia. There is this advantage, however. The apparent increase of weight on the beam when the drum is accelerated by the string *D* measures the force required to accelerate the drum regarded as concentrated at its axis. The friction and the force required to accelerate the mass *F* are eliminated, and we have the ideal case of the acceleration of a frictionless pulley under the action of a known moment.

(For discussion, see page 546.)

SOME QUESTIONS RELATING TO THE COURSE IN MECHANICS.

BY EDWARD R. MAURER,
Professor of Mechanics, University of Wisconsin.

The purpose of this paper is not so much to furnish but rather to elicit information. The information sought will interest others, I hope, and this is my justification for taking any time of this meeting for such purpose.

Examination of the curricula of a number of engineering colleges shows considerable differences in plan and scope of the instruction in mechanics. Some of of these are due to differences in organization of the colleges and constitution of their faculties, but others are due to real differences of opinion as to what is best for the student regarding work in mechanics.

At Wisconsin, the student begins mechanics as a part of physics. He devotes five credit-hours per week (suitably divided between lecture, recitation and laboratory) for about one half a semester to the subject. This we call "elementary mechanics." Soon, but not immediately, after completion of this work, he begins a course in the department of mechanics which can be briefly described as statics and dynamics, especially of solids. No laboratory work and no classroom demonstrations are included in this course; it is in part a repetition but more an amplification of the elementary course, particular atten-

tion being given to instruction and drill in application of principles. This course we may call "analytical mechanics" and the two as "theoretical mechanics." I have given this description of courses to explain what I mean by elementary and analytical mechanics.

I find that in most colleges the theoretical mechanics is given in two doses, so to speak, as at Wisconsin. But among these there is an important difference. In some, the analytical follows closely the elementary course, and all the mechanics, including strength of materials, appears early in the curriculum. In these colleges, mechanics is evidently regarded as preparatory to the more professional studies which follow. In a fewer number of colleges, the elementary mechanics apparently suffices for the later professional studies; and in his senior year, the student takes up analytical mechanics, and it is regarded, I presume, just as professional and practical as other senior studies. Now I recognize some advantages and some disadvantages in this postponement of analytical mechanics, but probably not all, and I—and others I think—would be glad to hear from those who have observed the results of this arrangement.

I believe there are some colleges in which theoretical mechanics is not repeated. If any of these are represented here, may we not hear about this arrangement?

At Wisconsin all the mechanics, including strength of materials, is given at the rate of five or six credit-hours per week. The question has been raised whether it would not be better for the student if it were given

at three or four per week for a corresponding longer period. The principal argument for the change is this: The subject is difficult for the average student to digest; under the present plan he is gorged all the time; the change would bring relief. Or, to vary the figure, now he cannot readily absorb the instruction; the proposed change would give time for it to soak in. I recently polled about seventy-five sophomores who had had about one semester of theoretical mechanics on a five credit-hours per week basis. Over ninety per cent. of them expressed their preference for the intensive or five hours arrangement. Teachers present who can throw any light on this question are respectfully requested to do so.

My next and last question is this: should the subject matter of mechanics be the same in all the various engineering courses, or should each group of students be taught separately, the materials of the subject being selected with special reference to the requirements of each? In other words, should specialization be extended to the instruction in mechanics or not?

If specialization is not attempted, administration of the instructional work is simplified somewhat. Thus the division of a large class into sections may be made more evenly, and the teaching staff and the equipment may be utilized more economically. Then, too, intermingling of civils, mechanicals, and electricals is continued for a time which is certainly good for them. All too early are the different groups of students isolated more or less in the larger colleges, each student losing much that he might gain by mere contact with his fellows of another group.

Briefly recalling the questions that I have raised I would recast them thus: (1) Is it advisable to put analytical mechanics late in the curriculum, say, in the senior year? (2) Is it advisable to take the student through theoretical mechanics only once? (3) Should work in mechanics be conducted on a 3, 4, 5, or 6 hours per week plan? (4) Should all groups of students be put through the same course in mechanics?

(For discussion, see page 546.)

THE TEACHING OF APPLIED MECHANICS TO ENGINEERING STUDENTS.

BY WALTER RAUTENSTRAUCH,
Adjunct Professor of Mechanical Engineering, Columbia University.

Previous to the discussion of the particular topic of this paper, it will be well to examine into some of the conditions surrounding the student during the time he is making preparation for his work in life. It cannot be denied that early impressions are lasting ones, and are important factors in establishing our point of view in after experiences. All our experiences together go to form our ideas and it is impossible to completely consider one particular field of experience without taking account of others related. It will therefore be necessary to consider the young man's training before he enters college and his consequent attitude of mind at that time, as well as to take account of what is demanded of him when he leaves college and goes out into life to make his way; what kind of experiences he will then have, and what is required of him that he may properly carry out his part. It will appear then that our topic in hand presents these several matters to our attention. First, the training received by the young man in the high school or academy with its consequent effect on his point of view. Second, the demands of the engineering profession. Third, the very best method of instruction in engineering schools in order to properly prepare the young man for the requirements of the

profession, and the bearing of all these to the teaching of applied mechanics.

Considering the first of these, we are brought to recognize the fact that the matter presented to students in preparatory schools must necessarily be elementary and fundamental and of such a nature that the interest of the student is awakened. With few exceptions, the general plan of the teaching is to fix certain facts in the student's mind, which facts must be committed to memory. Events in history are learned in chronological order together with epochs in literature and science.

Some fundamental laws in physics and chemistry are learned, as well as elementary principles in mathematics. The memory is the principal function of the brain which has been exercised, and the student has gathered information by absorption. There has not been much reasoning required of him to the end that he used the data he has gathered in drawing general conclusions.

This is also usually true of what laboratory instruction he receives. He observes and records the data of his observations as so many facts. He very often does not connect these phenomena observed in the laboratory with daily experiences but rather remembers the occurrence in connection with the particular circumstances in which it was presented to him.

And so we find that the student coming to the university to receive an engineering education has been started along the path of absorbing information. His experience has established in him a certain point of view with which he approaches his university

studies. The majority of our students come equipped with habits of study and ideas in regard to what constitutes a successful accomplishment of work which is entirely false, and which requires considerable discipline to eradicate. Many feel that they have finished certain subjects, such as arithmetic and geometry, and that they are not expected to be accurate in such minor details. They feel that simple mistakes in arithmetic are not to be considered if the correct "principles" have been used in the solution of their problems. Furthermore, we find them taking up their studies with a view to merely gathering so much more data, more formulas, as is often shown by the much repeated question when a problem is given for a solution, "What is the formula?" The analysis of the problem does not seem to be the first thing that occurs to them upon the presentation of the problem, nor do we usually find them holding a correct interpretation of the formula selected for application. Quite often a solution is attempted by blind substitution in the hopes of reaching a satisfactory result.

On the other hand, let us consider what is required of the engineer, what these young men must be fitted for upon their leaving college. It may be said that the engineer is essentially one who, by virtue of his understanding of the principles of the industrial sciences, is able to solve commercial problems. The variety of the problems is great, and in no two are all conditions found alike. He must, therefore, be an analyst, and classify his conditions, co-ordinate his data, and be able to recognize in all the details of his problems, the principles which are to be applied. It

is not enough for him to know scientific principles, but he must be able to recognize the circumstances in which they may be enveloped. All factors in his problems must be considered. It is not enough to select certain factors and upon these develop a theory, for there are factors which must be sought as well as those which are apparent. Whatever he does must stand the test of time and service, and every future circumstance that may surround it. Whether he builds a bridge, or factory, or organizes a system of management, every circumstance liable to arise must be accounted for, and included in the theory upon which he plans his work. Should his work fail, he cannot plead that the principle was right. He has failed, and no other conclusion can be drawn but that his reasoning was not correct. No partial theory serves his purpose, for he is required to produce results. It therefore seems that the duty of the engineering schools as established by these several conditions is to overcome such tendencies in the student which lead to the haphazard gathering of information, and to so direct his thoughts that each principle learned and all data collected become instruments in his hand for the analysis of every problem put before him.

To continually impress the student with the fact that all factors of a problem must be accounted for; that he is not solving academic problems to be recited on, but that he is preparing himself to solve problems of a similar nature in his future work as an engineer. All principles must be impressed upon him so that he recognizes their varied applications.

It is believed that the first may be overcome by insistence upon correct methods of work, often requiring much patient explanation and repetition on the part of the instructor. Even if the work of careful analysis prevents the solution of many problems it should not be neglected.

The latter end may be accomplished by frequent presentation of problems from engineering practice, enveloping all principles presented in such circumstances as may readily be found in engineering practice. While it is true that in the development of a theory or the establishment of a principle it is necessary to include merely the simpler factors in the beginning that the student's understanding may not be confused, yet great care must be exercised as to how these principles may finally be left in the student's mind, and that no practical examples be given which are liable to establish such examples with a partial theory.

And so we come to the question "How should the subject of applied mechanics be taught to engineering students in order that it may lend itself to such development as it seems necessary for the student at this time? How may its subject-matter aid toward a solution of this problem?" It is a very difficult matter to completely define applied mechanics as it is generally understood in our schools of engineering. As generally taught its subject matter is confined to a consideration of the principles of statics, dynamics, hydraulics, and the strength of materials. It is a subject fundamental to all real engineering subjects for there is barely a problem in engineering

which does not involve something of applied mechanics. It seems therefore, that this subject should be presented in the same manner as engineering problems present themselves, in order that the student may be trained in the methods with which he must work in the future.

The ability to recognize principles is just as much of a faculty to be developed in the student and often more important than the mere impressing of the principles themselves. We hear much discussion on the point that the student of engineering should have a broad, fundamental training, but I fear that too little recognition is taken of the fact that the principles are useless if the application is not apparent, and if the principles are not recognized in the problems which present themselves for solution. Furthermore, when the principle is enveloped in circumstances which appeal to the student and which are at once apparent as practical his interest is aroused. No subject can be successfully pursued unless the student clearly sees the meaning of things. Can we imagine a more irritating thing to a young man eager after insight into engineering work than to have to concern himself continually with working such problems as amuse the physicist. While it is necessary that the student fully comprehend the broad application of general principles, there is some danger of there not being enough application on the real engineering side to satisfy the student that he is getting something which he has come to learn and to maintain his sympathies. In the application of these principles to engineering problems there also lies

this difficulty, and that is, the partial consideration of factors entering into a practical problem chosen to illustrate a principle. This very often results in too much importance being placed upon minor factors. Sometimes we find ridiculously accurate results obtained in the solution of certain problems and no account taken of other factors not particularly needed in illustrating the principle, which factors, should they be included, would partially or entirely overshadow the principle that is desired to be demonstrated. Sometimes very false and harmful impressions are left in the student's mind, and are a source of much difficulty in getting the student to fully comprehend problems of a similar nature arising in his subsequent work. Even though it may not be necessary to use all the factors entering into a practical problem, the partial solution of which illustrates the principle, it certainly should be called to the student's attention.

Another matter that should not be neglected is the pointing out of the limitation of formulas based on irrational theories. There seems to be no way to avoid the improper use of formulas other than to thoroughly drill the student in their derivation. Most students have great faith in everything printed in books and can hardly realize that formulas have limitations. There is so much matter at the present time appearing in the various technical papers from which improper conclusions represented by formulas have been deduced that gross errors are liable to arise by their improper application. As well as requiring the student to analyze the foundation and limi-

tation of formulas, I believe that too much stress cannot be put upon the student's direct interpretation of formulas. There is quite a common belief among students that when a formula has once been derived that there remains merely the remembering of the formula as a formula only and not the laws which it may express. This can only result in the blind solution of problems.

One of the most useful means for getting the student to properly interpret formulas is laboratory instruction. Here, as in no other place can it be required that the student use his thinking powers. Laboratory courses of instruction are quite different in the many schools throughout the country, but I believe that most of the schools are beginning to recognize the fact that the best results are obtained when the student is required to apply what he knows to the determination of fundamental laws rather than to merely go through with routine standard tests. If the student is given some real problem to solve with facilities at his disposal for testing his ideas and obtaining the data which his general understanding of the problem shows him that he needs, he begins to understand what he is about. He is required to think, and not merely to fill in certain columns of log sheets which may or may not have a meaning to him. How easy it is for a student to come into the laboratory with the experiment already set up, be assigned to reading a certain instrument, record his readings in one of the columns of the log sheet, get certain results from printed instructions and formulas and utterly fail to understand what it

is all about. It can hardly be disputed that this is a very convenient way to get students through the laboratory without much trouble to the instructor, but can it be said that it is the best for the student? Let the student be given real problems to solve in the laboratory, so that he must prepare his own log sheet and decide what data he must obtain in order to solve his problem. No student should be allowed in the laboratory until he has proved to his instructor that he knows what he is after and has a full understanding of his problem.

The tendency in engineering practice is to standardize as much as possible, but when it is realized that this standardization permits of the employment of less competent help who need not necessarily be very strong in analysis, how foolish it seems to apply this to methods of instruction primarily intended to instruct the student in fundamental laws. With these few remarks, I have attempted to point out some of the principal features in the teaching of applied mechanics which my experience has shown me must continually be kept in mind in order that the work in that subject may become more efficient. One who has had engineering experience can easily realize the importance of these remarks. He understands the engineer's point of view, how he must attack his problem and apply his theories and I believe such an one can more satisfactorily lead his students to correct understanding of the subject than one who looks at the subject from the academic point of view, and cannot fully comprehend all the relations of the principles he is explaining to engineering practice.

Joint Discussion.

Dean Kent: "Much careful repetition by the instructor" is said to instil the principles into the boy. I think the trouble with the teachers is they do too much oral repetition. They forget that nine tenths of what they say goes into one ear and out of the other. The proper thing is to have a textbook written in good English, in words that cannot be misunderstood. One trouble with the textbooks is, they have not been carefully edited for the purpose of seeing whether the sentences are rhetorically correct and clear. They lack unity. In regard to teaching mechanics, the other day I sprang a quiz on the senior class, calling for the fundamental equations of elementary dynamics. I asked them to explain how they got the equations and give an example showing that they understood how to apply them in a practical example. The result was rather startling; they had the formulæ by memory, but they could not show their derivation, and in their application many of them showed a lamentable lack of knowledge of the first principles.

Dean Woodward: I think three hours a week is not too much, and is not extending a subject over too long a time. Some of the principles require a good deal of study. They should have the same course in mechanics, in my judgment. The examples brought in are from all the realms of applied mechanics. These things should be taught as early as the middle of the sophomore year, and go on continuously. The examples we bring in should not all be from engineering work. They should be abstract, some of

them; some of them should be ideal till the ideals are clear. Then they should be applied to real problems until they get a clear grasp of the important truth that every ideal solution is a more or less close approximation to a real solution, or to the solution of a real problem. Thus the student learns that ideal problems become useful in dealing with real ones.

I don't think it is wise to give men purely numerical examples. The general underlying thought is best given in general terms, so they are not too much distracted by numerical values. I would have them learn the best arrangement for their work, the best style for their work, the clearness of it on paper and the logical order in which they should put things down, and finally the necessity for the absolute numerical accuracy of all their results. While you are emphasizing the arrangement and accuracy you should begin with something perfectly familiar in principle.

In regard to the language we find in our books, I endorse what Professor Kent says. We find problems stated so badly that they may mean one thing or they may mean another. Sometimes you have to guess at the meaning by the answer that is given. There is too much looseness in the English.

PROFESSOR BENJAMIN: At this time of the year I am. always in a particularly humble frame of mind. I feel that if the Lord will forgive me for what I have left undone during my teaching the past year; I will try to do better next year. So I do not feel like criticising anybody. I suppose those who take my men after I have taught them will have the same feeling toward me that I have toward those who pre-

ceded me. I do find all the time this lack of appreciation of the application of mathematics and physics and mechanics to actual work. I taught mathematics myself years ago, and know what the difficulties are. I believe one great difficulty is the attempt to cover too much territory. I have been glad to hear the opinion expressed here by so many eminent educators that we ought to simplify our curricula rather than elaborate them. If a boy has firmly fixed in his mind the elementary principles of mathematics, physics and applied mechanics, he is a pretty good engineer, I don't care whether you call him mechanical, civil or electrical. You can take him, and in six months make any kind of an engineer you please out of him. I wish we could get men that can use any simple mathematics, simple physics and mechanics, and use them right, in everyday problems.

THE ENGINEERING EXPERIMENT STATION AT IOWA STATE COLLEGE.

BY G. W. BISSELL,
Ex-Professor of Mechanical Engineering, Iowa State College.

At the New York meeting of this Society in 1900, Dean Marston, of Iowa State College, presented a paper* entitled "Original Investigations by Engineering Schools a Duty to the Public and to the Profession." The entire paper should be read in this connection because the ideas therein recorded had become and have since been the dominating ideal of the Engineering Experiment Station at Ames, Iowa.

The substance of a few paragraphs of Dean Marston's paper is as follows:

"In a now recognized important sense, the entire public must be considered university students, and by frequent publications, addressed to different classes of people, by extensive lectures, and possibly by correspondence instruction, the modern university must seek to educate this greater student body. Besides this, no university or department thereof can be considered to be doing living, vital work, unless in addition to its work of instruction it is carrying on original investigations. Otherwise its work will be purely mechanical. No student can be properly educated without bringing him into such close relation with veiled truth that he feels the very throb of her pulse, and receives direct from her the inspiration to become himself a searcher after the truth.

* PROCEEDINGS, S. P. E. E., Vol. VIII., p. 235.

"So, too, the function of the modern technical school should be in its particular field, closely similar to that of the university, as outlined above. . . . In addition to educating engineers the technical (engineering) school should, by special courses, train teachers for all the industries and commerce of modern civilization. . . . By the publication and distribution of frequent bulletins on technical, industrial and commercial subjects, by its faculty taking part in meetings and conventions, etc., the technical school should seek to educate the industrial and commercial public in the application of science to their work.

"It is the special object of this paper, however, to make a plea for systematic, original investigation work in technical schools." . . . "Such investigations are of two kinds. First, those mainly of professional interest and value; second, investigations whose results have a considerable commercial, industrial and public, as well as professional, value."

In the current catalog of Iowa State College, under the caption "Engineering Experiment Station," is printed the following:

"While the principal business of the several engineering departments of the college is to give instruction to their students, the fact is recognized that the state contributes largely to the financial support of the college and that in return, not only should the college give tuition to the youth of Iowa, but it should contribute as much as possible to the successful carrying on of industrial interests of the state. By the establishment of experiment stations the national government has recognized the duty of the land grant

colleges to the agricultural interests. The engineering departments of this college believe that it is their proper business to aid the other industrial enterprises of the state. With this thought as the motive, the several engineering departments have undertaken during the past ten years and will continue in the future to undertake to carry on investigations of interest and value to the industries of Iowa, as need therefore may arise, and in so far as the funds available will permit. A number of pamphlets and bulletins giving the results of some of these investigations have already been published, and have been received with much favor by the people of the state. By strong resolutions numerous industrial and public organizations in Iowa have expressed their approval of this work.

"In recognition and furtherance of this work, the Thirty-first General Assembly has appropriated a specific annual sum for the establishment of an engineering experiment station, for carrying on and publishing bulletins of investigations of value to the industrial and municipal interests of Iowa."

So much for the *ideals* of Iowa and her state college in this field of engineering experiment station work.

As to the means and methods of following the ideal towards attainment, it may be said that the "sinews of war" for many years consisted chiefly of congenial and determined workers and a rather meagre material equipment, the latter barely sufficient for the instruction of yearly increasing classes of eager and industrious students, and still more meager financial resources. Nevertheless, in this period, eleven bulle-

tins on sewage disposal, building materials and fuels, were published and circulated, aggregating 225 pages, and the *Iowa Engineer* was launched. The latter was a private enterprise of the heads of the engineering departments and was supported mainly by its advertising pages.

This period extended from 1897 to 1904. In 1904 the "recognition" by the state of Iowa was secured in the form of the "munificient" annual appropriation of $3,000, to be expended solely for engineering experimentation and the publication of bulletins, and also the college was made the "State Highway Commission" with an additional annual grant of $3,000. Four years later the first-named annual grant was increased to $3,500.

After the recognition act, the engineering experiment station was formally created as a distinct department of the engineering work of the college and a staff selected which consists now of the president of the college, *ex-officio,* A. Marston, director, and Professors Meeker, Beyer, Spinney and Bennett, these men representing respectively civil engineering, mechanical engineering, mining engineering and ceramics, electrical engineering and physics and chemistry.

Mr. P. E. Ellis is assistant chemist and gives his time to station work and is paid from its funds.

In this second period of the history of the station, bulletins have been issued six times per year, nominally, seven having appeared to date and others in press or nearly ready for the printer. Material for others is being gathered and new investigations are outlined.

A synopsis of the entire series of published bulletins is presented herewith:

LIST OF ENGINEERING EXPERIMENT STATION BULLETINS.

Bulletin No. 1.—The Iowa State College Sewage Disposal Plant and Investigations (now out of print). This bulletin describes the college plant, the first in the state, and gives the results of the first year of operation, including bacterial and chemical analyses. 21 pp., 6 cuts.

Bulletin No. 2.—Bacteriological Investigations of the Iowa State College Sewage. Results from September 1, 1899, to September 1, 1900. 22 pp.

Bulletin No. 3.—Data of Iowa Sewage and Sewage Disposal. This bulletin gives a number of gaugings and analyses of Iowa sewage from different towns, and of various kinds, together with the detailed results of the operation of the college sewage disposal plant from May, 1900, to May, 1901. 27 pp., 5 cuts.

Bulletin No. 4.—Bacteriological Investigations of the Iowa State College Sewage Disposal Plant. Results from 1898 to 1902. 19 pp., 3 plates.

Bulletin No. 5.—The Chemical Composition of the Sewage of the Iowa State College Sewage Disposal Plant. Results from 1898 to 1902. 11 pp.

Bulletin No. 6.—Tests of Iowa Common Brick. This bulletin gives the results of several hundred tests of seven different varieties of common brick manufactured in Iowa. Crushing, transverse breaking, absorption and freezing and thawing tests are given in each case. 23 pp., 28 cuts.

Bulletin No. 7.—Sewage Disposal in Iowa. This

bulletin gives detailed descriptions, usually with plans, of all sewage disposal plants in Iowa up to December, 1903, with the history of sewage disposal in the state, and full details of the operation of the several plants, including chemical and bacterial tests of efficiency. This paper was awarded the Fuertes Medal by Cornell University, June, 1904, and the Chanute Medal of the Western Society of Engineers for 1903.

Bulletin No. 8.—This bulletin gives the results of several hundred tests of seven varieties of dry-press brick commonly used in Iowa. Crushing, transverse breaking, absorption and freezing and thawing tests are given in each case. 19 pp., 8 cuts.

Bulletin No. 9.—Notes on Steam Generation with Iowa Coal. This bulletin gives a summary of a number of analyses of Iowa coal and tests of their heating power together with a discussion of the special difficulties encountered in burning Iowa coals and the best methods of overcoming these difficulties. 16 pp., 3 cuts.

Bulletin No. 10.—Dredging by the Hydraulic Method, by Geo. W. Catt, President of the Atlantic, Gulf and Pacific Dredging Co.

Bulletin No. 11.—An Investigation of Some Iowa Sewage Disposal Systems, by L. H. Pammel and J. B. Weems.

At this point the form of the bulletin was changed to a periodical published six times a year, and the system of numbering the issues was changed accordingly.

Volume II., No. 6.—The Good Roads Problem in Iowa. This was the first bulletin published by the

Iowa State Highway Commission and it gives a general discussion of the good roads problem in Iowa, with instructions for building concrete culverts and for making king road drags.

Volume III., No. 1.—Tests of Cement. This bulletin gives a general discussion of the properties of cement, together with the results of several hundred tests made in the laboratory of the Engineering Experiment Station. Standard specifications for cement are also given.

Volume III., No. 2.—State Railroad Taxation. This is a discussion by Professor F. C. French, Associate Professor of Railway Engineering at the Iowa State College, on the different methods which are employed in taxing railways.

Volume III., No. 3.—Steam Generation with Iowa Coals. This bulletin reports the results of a number of investigations on mechanical stokers with Iowa coals, together with a summary of the results of the government tests on Iowa coals, hand fired. By Professors G. W. Bissell and W. H. Meeker.

Volume III., No. 4.—Incandescent Lamp Testing. This bulletin gives a comparison of the various kinds of incandescent lamps which are on the market, with respect to their initial candle powers and efficiencies and a determination of the ratio between the mean spherical and horizontal candle powers.

Volume III., No. 5.—Steam Pipe Covering Tests, with a special object of determining the value of steam pipe coverings of varying thicknesses, based upon the results of these tests and compiled by Professor Wilson.

Volume III., No. 6.—Sewage Disposal in Iowa, 1904–05. This bulletin, which is now nearly ready for the press, will continue the subject of sewage disposal in Iowa where left off by bulletin No. 7 and will give a description of all plants constructed since 1903. It will also give the results of operation of every plant in the state during the years 1904 and 1905, including chemical and bacterial tests of the efficiency of each.

"The Good Roads Problem in Iowa," published as Volume II., No. 6, of the Engineering Experiment Station Bulletins. This gives a general discussion of the good roads problem in Iowa, including the geological structure, topography, road materials, and other important features of the road situation of the different sections of Iowa. It also gives the general facts as to the mileage of highways in the state, the amount of traffic thereon, expenditures of road money, etc. It gives a discussion of the methods of maintaining earth roads by dragging, with plans for constructing drags and instructions for using same. It also gives a discussion of concrete culverts and some instructions for building the same.

"Manual for Iowa Highway Road Officers." This is a publication of 102 pages prepared for the use of the road officers of the state and giving a much more full discussion of road laws and other features of the road situation in Iowa than in the bulletin above referred to.

"The Annual Report of the Iowa State Highway Commission, 1904–05." This is a publication of seventy-five pages which gives a detailed report of the operations of the commission during the first year of its existence, including a detailed statement of the

expenditures. It further gives quite an extensive discussion of many features of good roads work and recommendations for legislation, several of which were adopted by the last General Assembly.

See also the files of the *Iowa Engineer*.

A good roads school is held each summer, for a period of one week, to which county supervisors and road commissioners are especially invited.

The station is called upon frequently to make tests or conduct investigations which are not of general but are rather of private interest. The expense thereof is borne by the interested party and the results held confidential, except as they may have a bearing on a problem of broader interest, when they are used in generalization without revealing identity.

Prior to the writer's connection with the Michigan Agricultural College as dean of engineering, he shared with Professor Meeker the honor and duties of the mechanical engineering side of the station work.

Those of us who have labored for engineering investigation work at Iowa State College have felt very keenly the limitations imposed by lack of financial support, but feel also some satisfaction in being among the pioneers in the field.

On the writer's own part he would say that he feels that the work has been well worth the while and that every engineering school receiving state aid should seek to the full measure of its powers to enter this field of public service, and that by so doing its efficiency as a school, properly so called, for the youth of the state will be increased rather than otherwise.

(For discussion, see page 571.)

THE ENGINEERING EXPERIMENT STATION OF THE UNIVERSITY OF ILLINOIS.

BY L. P. BRECKENRIDGE,
Professor of Mechanical Engineering and Director of the Engineering Experiment Station, University of Illinois.

The engineering experiment station at the University of Illinois has now been in existence nearly four years, having been established by action of the board of trustees in December, 1903. The first two years were largely a period of preparation and planning, the main efforts being directed to the extension of the equipment of the engineering laboratories. At the same time a beginning was made along a few important lines of investigation. The second two years have witnessed a general extension and elaboration of these investigations and the further extension of our equipment, until now we may be said to be fairly started on our work.

As many of the members of this Society are already familiar with the work of the station, it will not be necessary to go into detailed explanations. Concisely stated, the purpose of the station is to carry on investigations along various lines of engineering and to study problems of importance to professional engineers and to the manufacturing, mining, railway, constructional and industrial interests of the state. The organization consists of a staff of eight members, representing with the director the heads of the different departments in the college of engineering. The work

of the college and the station is thus very closely related.

There were two main factors leading up to the establishment of our station. In the first place, in all engineering colleges experimental work has been in progress for many years, and valuable results have been attained. We have all felt the desire to extend and improve our work. The main obstacle to true research work has been lack of funds. To extend our investigations so as to meet and solve the engineering problems of the state as expressed in demands for tests of its fuels, its constructive material, its railway operation, and its manufactured products was one of the factors in the recommendation resulting in the establishment of the engineering experiment station in connection with the college of engineering. In the second place, for a number of years the agricultural industry of Illinois has been greatly benefited by the work of the agricultural experiment station. During the first year of its existence this station was supported by the United States government. Subsequently, the increasing demands for investigations of various kinds rendered additional funds necessary, and the state was called upon for assistance. At present the agricultural experiment station receives regular support from the state at the rate of about $95,000 per annum. The benefits to agriculture resulting from its investigations are too well known to need comment. The expenditures of the state in its support have been repaid many times. Millions of dollars have been added to the wealth of Illinois through the investigations on corn breeding,

the soil surveys and fertility experiments and the work of eradicating insect pests. It is our hope that the engineering experiment station may stand in the same helpful relation to the great mining, transportation and manufacturing interests of Illinois. What has been done for agriculture may well be done for manufacturing. The state's investments in the agricultural experiment station have been rewarded with large dividends in the way of increased soil fertility and increased and improved agricultural products. Surely as large dividends await similar investments in the engineering experiment station. Important problems in agriculture have been and are being successfully solved by the agricultural experiment station. Important and difficult problems of engineering confront the manufacturer and power user, and press for solution. It is the aim of the engineering experiment station to assist in the solution of these problems and thus to aid and uplift the engineering industries of Illinois.

Work Already Accomplished.

The first work undertaken by the engineering experiment station was an investigation of reinforced concrete and the properties of concrete affecting reinforced concrete construction. Considerable work has been done, making it one of the most extensive and systematic investigations on reinforced concrete made in this country. The work of the present college year on beams, T-beams, hooped columns, culvert pipe, etc., is expected to give valuable data on this type of construction. Various tests on timber and iron and steel have also been made.

The importance to Illinois manufacturing interests of information concerning the use of high-speed tool steels led the station to make investigations in this field. The drainage of earth roads was also a very natural subject to present to the people of this state. The resistance of tubes to collapse has been made the subject of most careful investigation by the department of physics. The extensive coal interests of the state coupled with the rapid growth of its manufacturing interests have suggested the extensive research work of fuel tests of Illinois coals which are in progress. There is evident necessity for investigations relating to track construction and timely experiments have been made on the holding power of railroad spikes. Much of the above work will be continued, but several new fields of investigation will be entered in the near future.

Facilities and Equipment.

The various laboratories of the College of Engineering, viz., cement, electrical, hydraulic, materials testing, mechanical, physics, railway and road materials, are well equipped in their several departments for carrying on investigations of many kinds. Extensive equipment has been purchased and installed for the especial use of the different departments in connection with their investigations. The rapid growth in attendance in the college of engineering has made it necessary to extend its equipment considerably, and while the apparatus thus provided is intended primarily for purposes of instruction, much of it is available at certain times of the year for purposes of

investigation. When a series of experiments has been concluded the equipment becomes a part of the regular laboratory to which it most naturally belongs.

The engineering experiment station is not quartered in any one building of the college of engineering, but its work and experiments go on wherever the needed facilities exist in the various departments. Neither is its work confined to the college of engineering nor within the limits of the university. Cooperation with other university departments, such as the college of science, state water survey and with the state geological survey enables it to complete many investigations, facilities for which are not available within the college of engineering. Cooperation with various departments of the federal government as well as with many industrial interests of the state is already assured.

Character of Work to be Undertaken.

In determining the character of the work which the station shall undertake, the most careful consideration will be given first to the needs and the interests of the state of Illinois. Fortunately Illinois is singularly favored in all the conditions requisite for a rapid and permanent industrial development, and its interests cover very wide fields of engineering activity. In view of its cheap and abundant fuel, its great agricultural wealth and its unexcelled facilities for the transportation of raw material and finished products, it is not surprising that Illinois is the second state in the union in agriculture and third in manufactures. With these great resources devolves upon us great responsibility in developing and husbanding them.

The testing of its materials of construction will always be a matter of importance for any state. The prevention of the waste of material growing more and more expensive, as wood, and the correct factors of strength of new materials, as concrete, are always subjects for the most careful investigation. To this work we are giving considerable attention, and the demand for the results of our tests on reinforced concrete which are being carried on under the supervision of Professor A. N. Talbot indicates the interest which is taken in this work and the necessity felt by architects, constructors and builders for the most exact information along these lines.

The work of the station will also extend into some fresh fields, seeking to discover new ways and means for economizing energy and materials, for the prevention of waste, for the perfection of labor-saving machinery, for safer methods of travel, and for surer sanitary methods of water supply and sewage disposal.

Fuel supply is of such prime importance in our industrial development that no effort will be spared in the introduction and promulgation of improved methods and processes in the mining, preparation and consumption of coal. From broad economical considerations wasteful methods of using coal, or the rejection of any combustible part as waste, are to be discountenanced. Exhaustive and careful experiments will be required before the best conditions can be attained. These experiments must include analyses of coals from all parts of the state, a determination of the best kinds of coal for specific purposes, best methods of burning Illinois coals, effects

of various methods of preparation, experiments on various kinds of furnace construction, etc.

Along the line of power production there is opportunity for much investigation. New problems are confronting both the builders and users of steam and gas motors. There is at present a noteworthy change from the reciprocating engine of large size to the steam turbine. Gas engines of large power have recently been installed, and the development of this type of motor bids fair to be more rapid in the near future. Still newer types of motors are being proposed from time to time, the gas turbine being one that at present occupies much attention as an attractive possibility.

For the user of power, the station can investigate questions relative to the economy of various types of power installations with given conditions of service. For the builders of motors it can investigate the new and perplexing problems that have arisen. The properties of the various fluids used in heat motors need careful study. Superheated steam is essential to the proper working of a steam turbine, yet many of its properties remain to be investigated. The properties of ammonia and other fluids used in refrigeration are not known accurately, and even the properties of saturated steam are based on Regnault's experiments made nearly seventy years ago. A careful investigation of the properties of heat media of all kinds, extending if necessary over a series of years, would furnish data of the greatest value to engineers, and would in addition be a noteworthy contribution to science.

Considerable work for the railroad interests has already been done by the railway engineering department of the university. This department owns jointly with the Illinois Central Railroad a dynamometer car equipped for steam road experimental work. With this car there have been made numerous road tests for the establishment of tonnage ratings. The department also owns a 200-horse-power electric car of the interurban type especially designed and thoroughly equipped for electric traction work. Railway work with both these cars will be prosecuted vigorously under the direction of the new school of railway engineering and administration recently organized.

It is expected that the experiment station will prove helpful to the manufacturing and building interests. In the first place, it will supply accurate data regarding the properties of the materials used in engineering structures and buildings. The laboratory of applied mechanics with its extensive equipment furnishes ample facilities for this line of work, and the reinforced concrete tests now in progress show great possibilities. In the near future, an extensive series of tests on cast-iron columns, and on various forms of steel and iron members is contemplated. Secondly, the experiment station will investigate manufacturing processes. As an example of this line of work the high-speed steel tests are cited. Thirdly, problems relating to design and construction will be studied, and all useful results will be published for the benefit of those engaged in design or construction.

As a rule the experiment station will undertake

only such investigations as will lead to results of fundamental importance, results that will be helpful to a large class of engineers or manufacturers. It will not, in general, undertake work of importance to individuals only, *e. g.*, the testing of a device or invention for the sole benefit of the inventor.

Relation to and Influence upon Educational Work.

It seems appropriate that a presentation of the work of our station should be made before this Society. It was our thought at the outset that the presence here of investigations would give inspiration to our students and add to the value of the instructional work of the college of engineering. We have found this to be true. The work of the station has had a marked effect in strengthening our instructional work. The contact with scientific experimentation and the methods of presenting the results in carefully prepared bulletins is a most helpful factor in the training of the young engineer. It is impossible for our experimental work to go on without attracting the attention of our students. The work must be carefully and accurately done; the preparation of charts and diagrams and the checking and rechecking of results and computations involve extreme care and accuracy. The fact that students see how problems are taken up, how they are solved, and the whole work satisfactorily presented, is perhaps the greatest single educational gain to them. They live in an atmosphere of research which they unconsciously absorb. They realize that failure to contribute each particular assignment with accuracy may result in the failure of the entire experiment.

The investigations of the station are carried on by the members of the staff directly, by fellows as graduate work, by members of the instructional force and by special investigators. Still there is abundant opportunity to make real use of student help in many tests and computations. The opportunity to participate in many of the tests is appreciated and eagerly sought by the students. They are interested in the direct application of theoretical principles to the solution of practical, everyday engineering problems. This illustrates the old pedagogical principle that when students are permitted to take part in real activities, they are more alert, interested and accurate than when merely carrying on exercise tests.

Some institutions have recently dropped the thesis requirement. This appears to be an unfortunate move. It has probably been caused by large classes and insufficient help and facilities. In the work of this station many subjects relating to researches in progress are capable of preliminary investigations as thesis work, and students pursue this work with unusual care and attention. Students are also greatly benefited by conferences and lectures by our special investigators who are always in readiness to advise students along the line of their particular problems.

Encouragement and aid are freely given to members of the instructional force who desire to take up some line of research. In this way much excellent work is done which necessarily reacts on the quality of class instruction, and at the same time proves a source of development and broadening. This work serves to keep us all in close touch with outside

engineering interests and practical everyday problems in the industrial world. While our bulletins record mostly the results of the station's own staff of investigators, there is also planned the publication of circulars, giving compilations of the results of experiments by engineers, industrial works, technical institutions and governmental testing departments. This opens up opportunities for our instructors who cannot undertake purely experimental work.

Each head of a department, being an active member of the station staff, is constantly on the alert to detect the possibilities of new lines of work and also to study the adaptation of certain men to certain lines of work and the possibility of developing investigators from our present body of students and instructional force. While it may be true that the genuine investigator and experimenter, like the poet, is born and not made, still much may be done to develop the spirit of investigation. This in itself is always an element of true teaching and the awakening of a more general spirit of investigation would undoubtedly be an element of strength in all our educational work.

The facilities of the station for research have made it possible to do real graduate work, and recent action of the trustees in providing for ten research fellowships in the college of engineering of an annual value of $500 will be a distinct gain to advanced engineering education. The special announcement of these fellowships has been sent to all members of this Society and further reference to this subject here is hardly necessary.

Co-operation.

It is very essential that great care should be exercised in the selection of subjects to be investigated. It is equally important that the results of the investigations should be published in such shape as will best serve the purposes of engineers and manufacturers. In order that these ends may be attained it has been thought desirable that there shall be organized conference committees on matters of widespread interest. Two such committees have already been formed. (1) A Conference Committee on Fuel Tests consisting of representatives from the following societies: State Geological Survey, Western Society of Engineers, Building Managers' Association of Chicago, Western Railway Club, Illinois Manufacturers' Association, Illinois Coal Operators' Association and State Electric Light Association. (2) A Conference Committee on Electric Traction Tests composed of representatives of the Illinois Traction System, General Electric Company and Westinghouse Electrical and Manufacturing Company. Meetings of these committees are held from time to time and general plans of work discussed. In this way the work of the station is kept in touch with the engineering and industrial interests of the state to the great advantage of all the interests concerned. It is planned to form similar committees relating to other lines of work whenever the importance of the investigations warrants it. It is hoped that suggestions may be proposed to the station from engineers, or from mining, railway, or manufacturing interests, to the end that

the work of the station may grow to be of real value to the commercial interests of the state.

Proposed Extension of Engineering Experiment Stations.

The encouraging reception which has been accorded the Illinois Engineering Experiment Station together with the generous support given the work by three successive legislatures leads us to believe that the same success would attend similar stations elsewhere, and to propose that such stations be established at a large number of our engineering schools. Such a station has already been established at the Iowa State College at Ames, Iowa, and the writer understands that a paper relating to the organization and work of this station will be presented to the Society at this meeting.

With the general establishment of such stations and with the demand for the kind of work which these stations should do there is every reason to believe that the federal government would soon give to such engineering experiment stations the same generous support that it is now giving to the agricultural experiment stations throughout the country. The reasons why this should be done are many and sound, and will readily occur to the members of this Society. The returns to our industries would surely be as great as has been the rich return to our agricultural interests from the investigations of their stations.

The magnificent research work done by the German Government in its extensive laboratories at and near Charlottenburg is now familiar to all members of this

Society. Shall we not have the foresight that will enable us to be prepared for the time when the necessity for the prevention of waste of our resources is upon us and such necessity is even more keenly felt than at present?

At the head of such a group of experiment stations might be a governmental department at Washington; but each state should aid in the support of its own station and such station should take up for investigation the continually enlarging and changing problems of engineering that affect its own industrial progress.

Why should not this Society place itself on record as in favor of such a movement? It would surely be a helpful uplift to advanced educational work in this country and with such a movement this Society should be identified.

Joint Discussion.

Professor Wood: Will Professor Bissell explain the necessary steps for the organization of such a station? Are there requirements that should be known? What special aids can the college give for the furtherance of the work?

Dean Turneaure: For some time we have had under consideration at the University of Wisconsin the formal organization of an experiment station, but up to the present time it has not seemed advisable. The engineering college has now a special fund,—four or five thousand dollars a year, to expend for research work. This is distributed among the departments and is expended for material, special apparatus and laboratory assistants. A considerable amount of

work is being done by this means and through the work of graduate students. We have felt it of great importance to keep the research work close to the instructional work, and our experience has shown that this is of very great help in the development of interest on the part of the students. The number of advanced students has increased in the last two years and the character of all laboratory work has improved. I think very likely however that the organization of an experiment station may be advisable. Without question the encouragement of research is extremely desirable.

PROFESSOR FRANKLIN: The suggestion Professor Breckenridge makes seems to be very serious. The Society should put itself on record in regard to it. I move that the suggestion of Professor Breckenridge be specifically referred to this Joint Committee on Engineering Education for recommendation.

DEAN RAYMOND: I question whether it is wise for all states to have these duplicate engineering experimental stations. One central station under the government would be more desirable. But since Illinois is so far ahead of the other states, it might be just as well to hold up the hands of Illinois and develop a large and valuable station there rather than spread all over the country with similar stations.

DEAN BISSELL: After the legislative enactment was made, the station was organized by the college authorities. The administrative work of the station is conducted by the Engineering Experiment Station Council and the funds are expended by the regular financial methods of the college. It is not wholly like the

agricultural stations. The bills are audited by the regular auditing committee of the college and paid by its treasurer; his report is made to the federal government. A biennial statement is made to the governor by the secretary of the board of trustees of the college as a part of his general report of college finances.

PROFESSOR WOOD: But is it a State fund entirely?

DEAN BISSELL: Yes.

LOOSE-LEAF NOTES FOR LABORATORY USE.

BY CHAS. H. BENJAMIN,
Professor of Mechanical Engineering, Case School of Applied Science.

Students who are working in an engineering laboratory need some sort of printed information to guide them, both in the conducting and in the reporting of experiments; the number of men which it is usually necessary for an instructor to handle in one section forbids individual attention to the extent which was formerly customary.

Books such as Carpenter's "Experimental Engineering" and Smart's "Laboratory Practice" are admirable for reference, but are too bulky and inconvenient for the laboratory. Some ten years ago I printed a handbook of about a hundred pages, bound in limp linen covers and suitable for laboratory use. This book contained descriptions of the various pieces of apparatus used at that time, with instructions for making experiments and some printed forms for logs and reports. This book answered its purpose fairly well for a time, but gradually became obsolete, as the scope and methods of the laboratory changed. Experimental work in any laboratory is of its very nature progressive and yesterday's methods are but stepping stones on the way.

The loose-leaf system of books possesses the same advantages in the laboratory that it has been shown to possess in commercial work. There is a fresh, clean book for each experiment, of such a character

that it can be conveniently used during the run; all loose sheets, such as logs and indicator cards, can readily be incorporated, so that when finished the book forms a complete record of the experiment. It can be changed from year to year, new matter added, and obsolete matter discarded; it is in the hands of every student, as he is unable to perform the experiment without it.

The same system can be applied to all notes, class-room, drafting room and shop. Occasionally the same printed leaves can be used in more than one department.

Some examples from notebooks used in the power laboratory of the Case School will serve to illustrate these points. The standard size of 6×9 inches has been adopted for all notes in this department. The drawings used conform to a similar standard, being 6×9, 9×12, 12×18 and 18×24 inches respectively.

The manila cover is the same for all experiments and contains only general instructions. On the outer page are blanks for the name of the experiment, for the names of the operators and for the various dates. On the first inner page are the general instructions for work in the laboratory and on the second inner page instructions for writing reports. These covers and all the material inside are perforated at the top with a standard bill file perforator and one of these instruments as well as a trimming machine are kept for use in the computing room.

The forms "A," "B" and "C" appended are otherwise self-explanatory. The first inserted sheet

contains the title of the experiment to be performed, together with references and list of apparatus; then follow the special directions for this experiment. The references are to be read and a preliminary report written, describing the apparatus and the nature of the experiment before the work is performed. Forms "D" and "E" illustrate what has been said. If it is thought necessary to have a printed form for final report, this is included in the book as issued. See form "F." In general, students prepare their own forms for logs on ruled sheets which are issued with the apparatus. These are of a different color to distinguish them from the report blanks and must accompany the final report. Students furnish the blank paper and the coordinate paper necessary to complete the book.

The preliminary report forms a part of the final report, so that it is not necessary to repeat description or sketches. When all this material is complete, it is inserted in the book in the order specified, when the latter becomes a history of the subject from start to finish. Any modification of the apparatus or of the method of conducting the experiment can be met by a change in one or two sheets of printing at trifling expense, and the book thus kept up-to-date.

Any discussion as to the amount of printed matter to be used in a laboratory is foreign to the purpose of this paper. The instructor may use as much or as little as his conscience will allow; he will still find that the loose-leaf has its advantages. Personally, I prefer to have a student do an experiment right and report it right with the aid of such printed forms as

may be necessary than to do it wrong and report it wrong on his own responsibility. I am also inclined to question whether the information given orally by the average instructor is as likely to be correct, or to leave as good an impression, as information in printed form.

Form "A." Page One of Cover.

POWER LABORATORY

Case School of Applied Science

Title ....

....

Name ....

DATES

Issue ....

Work to be done ....

Reported ....

Report returned ....

Report accepted ....

Signed ....

.... Instructor

Names of students assisting in experiment:

....

....

(See instructions on inside of cover.)

FORM "B." PAGE TWO OF COVER.

INSTRUCTIONS

Work will be assigned about one week in advance. During this time references must be read and a preliminary report prepared explaining nature and object of experiment. This report must be written in ink on standard 6 x 9 white paper. No student will be allowed to perform an experiment until his report has been presented.

As the schedule of experiments has been prepared beforehand, each student must report for work at the date and time indicated on the cover of this report. Men who are absent or tardy will be conditioned on that particular experiment.

The list of apparatus needed will accompany this report. Obtain this apparatus from the instructor in charge and see for yourself that you have what is required. Note carefully any number or mark on each piece of apparatus used, and record this in your report. **This is very important.**

Clean all instruments when you are through, and return them to the apparatus room. Any faults or breaks must be reported as soon as discovered. Remember that you stand charged with apparatus until it is returned in good order.

Always use blue log sheets for original records of experiments, and preserve these to hand in with your report.

(See inside of back cover for form of report.)

Form "C." Page Three of Cover.

The report when completed should include the following items:

1. Title and object of experiment.

2. List of apparatus used, with numbers, sizes, etc., and sketches of any special or new apparatus.

3. Diagram of arrangement of apparatus, in case several pieces are used.

4. Description of method used and explanation of formulas.

5. Observations in tabular form.

6. Results, with tables and plotted curves.

7. Conclusions.

8. Original Notes of Test.

All work except original notes must be done in ink and neatly executed. Sheets must be arranged so as to bring matter in order indicated, must be perforated at top and fastened inside cover with brass clips. Standard size is 6 x 9 inches.

One week is allowed for preparation of report. Reports which come in late will be graded on a sliding scale.

In preparing preliminary reports, read references given and try to understand reason of experiment and principle of apparatus. In performing the experiment use common sense and a reasonable amount of accuracy.

Form "D."

8. STEAM ENGINE AND INDICATOR

Subject:

The adjustment and care of the indicator; its attachment to the steam engine and the taking of indicator diagrams:

References:

Crosby Instruction Book: Chapters II. and III.
Benjamin: Laboratory Notes, pp. 67, 68.
Peabody: Steam Engine Indicator, pp. 41, 42.
Carpenter: Experimental Engineering, Chapter XVI.

Apparatus:

Indicator Nos. .... and ....

Springs Nos. ....

Speed Counter No. ....

Directions:

Practice taking indicator apart and putting it together until this is thoroughly understood. Attach to engine; adjust cord length and pressure of pencils on papers.

Take cards on signal from whistle and observe the following routine:

1. Put on paper.
2. Adjust pencil pressure.
3. Connect cord.
4. Open valve.
5. Take card and close valve.
6. Take atmospheric line.
7. Unhook cord.
8. Remove paper.
9. Mark on paper the following data:
   a. Number of card.
   b. Which end of which cylinder.
   c. Boiler pressure.
   d. Revolutions per minute.
   e. Scale of spring.
   f. Time of taking card.
   g. Name of person.

The directions given in the instruction book must be carefully read and followed.

The indicator is a delicate and an expensive instrument and *must be carefully adjusted and handled.*

Form "E."

31. STEAM INJECTOR

Subject:

Working tests of injectors to determine the capacity and efficiency.

References:

Kneass: Injectors, pp. 135–148.
Hutton: Heat Engines, chapter XXIII.
Catalogues of Injectors.

Apparatus:

Platform Scales Nos. ....

Thermometers Nos. ....

Thermometer Wells ....

Gages Nos. ....

Measuring Scale ....

Directions:

1. Weigh water in tank No. 1 and note level. Keep water at same level in this tank until test begins. See that tank No. 2 is empty and valve closed.

2. Start injectors according to directions in catalogue and allow water to go to waste until test begins.

3. Close throttle valve on discharge SLOWLY until back pressure is slightly greater than steam pressure.

4. Turn discharge into tank No. 2 and water off from tank No. 1. Note time, pressures and temperatures.

5. When water is nearly out of tank No. 1 stop test by shutting off injector and closing valve in discharge. Weigh both tanks.

Repeat the above on at least two other injectors, testing one locomotive type: one of double type and one automatic.

Form "F."

Date ....

REPORT OF TEST ON ENGINE LATHE

....

....

.... Lathe

Swing .... Length of Bed ....

No. of Test	1	2	3	4	5
Large diameter of work					
Small diameter of work					
Depth of cut					
Length of cut					
Amount of metal removed (cu. in.) ..					
Weight of metal removed					
Surface speed, feet per minute					
Feed (per inch)					
Weight of metal per hour					
Weight of metal per hour per H. P. ..					

Kind of metal (work) ....

Kind of steel (tool) ....

Shape of tool ....

Discussion.

Professor J. D. Hoffman: We use the loose-leaf system in every department of our work, and it is very satisfactory. Besides the standard sheets, the book dealers keep on hand blank paper, cut and punched, the size that is used in the university, and the students use the blank sheets for their calculations. I find it very satisfactory in machine design, and in all forms of reports. When a student calculates a certain part of his machine he keeps the original calculations. Where the loose-leaf system is not used, a man makes his calculations on any kind of paper and they are destroyed. This loose-leaf system gives him the privilege of putting the original calculations in with his report, and in case of any error they can be referred to at any time. The size of the paper is $8\frac{3}{8} \times 10\frac{3}{4}$, about the size of an ordinary letter sheet.

Professor C. R. Jones: In teaching laboratory work my experience coincides closely with that of Professor Benjamin, especially in regard to the amount of instruction that should be given to students beginning laboratory work. If they are set to work on some apparatus that has to be handled carefully, they need all the help that they can get. After they have learned the use of measuring instruments, and begin to use the instruments in testing machines and materials, or some other piece of apparatus, then I leave them more and more to work from their own resources.

Professor Brackett: I have recently been requiring the original records and computations to be kept in a permanently bound book. The final report is

made on the loose-leaf system. I think there are disadvantages as well as advantages in the loose-leaf form. Accuracy and system in making the original records is very important, and with a loose-leaf book there is certainly more chance to modify and repair an unsatisfactory record than with a permanently bound book in which everything once entered must show in some way, either by erasures or by insertions.

THE TEACHING OF ELEMENTARY MACHINE DESIGN.

BY J. D. HOFFMAN,
Associate Professor of Engineering Design, Purdue University.

1. *General Statement.*—The teaching of machine design is a subject that has been touched upon very little in the engineering papers, regardless of the fact that it deals with a line of work that is very important to the engineer. The author believes that this is a subject which should receive its full share of attention from those vitally interested and presents this paper for your consideration. It is not to be considered as a resumé of all the systems of handling the subject, but is rather to be understood as illustrative of the development of the subject in the university with which the author is connected. Because of the importance of the subject, therefore, and because of a desire to improve existing conditions, it is hoped that this presentation will stimulate discussion and eventually serve to develop an ideal course in elementary machine design.

2. *Preparation for the Course.*—To be effective in the work of design, the student should be familiar with shop methods, so as to eliminate expensive processes in shop production. He should also be familiar with the strength of the materials usually employed in machine construction, as well as to be able to apply the principles of mechanics and mechanism to the solution of constructive problems. These things are

very important; the first one should be considered a prerequisite, while the others may be taken, if necessary, in parallel with the work in design.

3. *Methods of Presenting the Subject.*—No hard and fast rule can be laid down concerning the teaching of machine design because the conditions to be met with in the various schools are all different. The ways in which it is taught number almost as many as the number of men engaged in the teaching. The point to be considered is not so much *what* to present as *how* to present it. All will agree on what constitutes the fundamental principles of design, but all will not agree on how to present these principles to a class in the best way, so that a class will get the most good in a minimum of time.

4. In speaking of the subject in the following discussion, the term machine design will mean all that the term implies, and not merely the proportioning of machine parts from standard tables, and drawing those parts on paper. The latter process gives ideas concerning the proportion and shape of parts, but gives no assurance to the designer concerning the stiffness and strength of the parts. To teach machine design satisfactorily, rational methods must be required wherever possible.

5. Two general systems are available, to be used in presenting the subject to a class; first, a number of isolated problems having no connection whatever with each other are presented and each one solved independently; second, typical machines are assigned, requiring first an analysis of the mechanism and then the design of each part, with special reference to its

surrounding conditions in the machine. The first method is probably handled with less effort to the instructional staff, but the second gives a thread and a meaning to the work, shows the connecting links between the mechanism of the machine and the design of its individual parts, and in general offers a more intelligent requirement for the course.

6. *Features Touched upon in the Course.*—Every course in machine design must elaborate the following points: First, analysis of the kinematics of machines; second, the design of links, columns, beams, bearings and shafts to withstand all the simple forces, tension, compression, shear, flexure and torsion; third, the design of the more complicated machine parts, such as pulleys, fly-wheels, gears, cams and machine frames.

7. All these features of the course may be given on the independent problem plan, where the assignments may be made out on cards and given to the student in any order whatsoever. The order in which they are assigned, however, will probably not be the order one would go about the work were he to attempt to design a machine containing the same parts; for this reason it seems advisable to select one or more machines which embody the respective features desired and in this way accomplish the object sought by the independent problem plan, and some things more which it cannot provide.

8. *Assignments for a Course.*—It is not probable that any one machine can be selected which will embody all the features desired in a course, hence the following suggestions may be found of value:

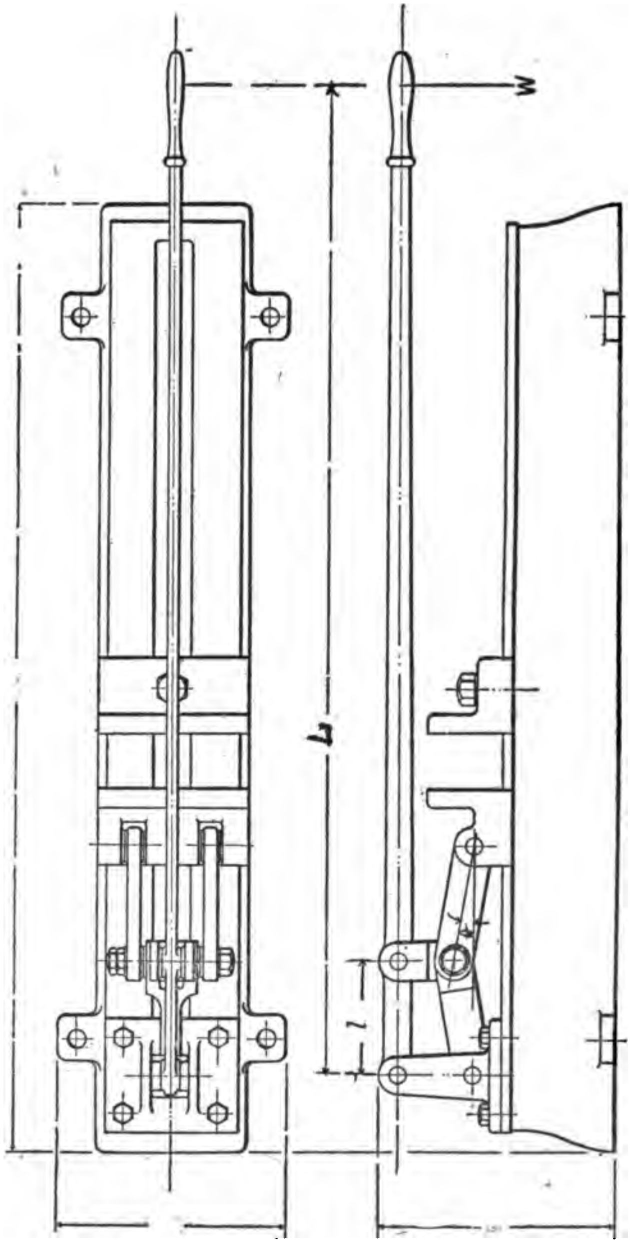

Fig. 1. Toggle Joint Press. Assignment: $W = (100 \text{ to } 150) \ldots.;\ L = (36'' \text{ to } 72'') \ldots.;\ l = (6'' \text{ to } 12'') \ldots.;$
$\theta = 10°$ **at Max. Load.**

(*a*) Some form of hand-lever press containing members in tension, compression, shear and flexure; represented by Fig. 1. Time (including one hour test or lecture each week), 60 hours.

(*b*) Elementary sheet in kinematics; represented by some form of cam or link mechanism for any typical machine. This is to be considered as a relaxer from the previous assignment. Time (including one hour test or lecture each week), 12 hours.

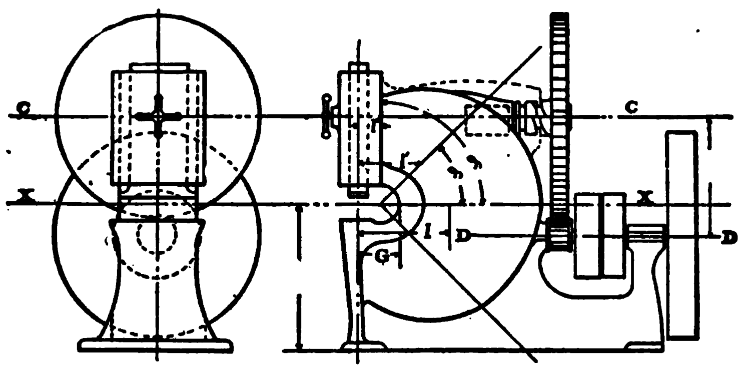

FIG. 2. Power Punch or Shear. Assignment: Material to be Punched ....; Size of Hole, Diam. and Depth ....; Depth of Throat ....; Number of Punches per Minute .....

(*c*) Some form of power machine which will review the simple forces mentioned in assignment *a* and include that of torsion; represented by Fig. 2. Time (including one hour test or lecture each week), 96 hours.

(*d*) Sheet in kinematics. Stephenson link, Walschaert link, or some form of inertia or centrifugal governor diagram. Time (including one hour test or lecture each week), 20 hours.

(*e*) Some form of machine using steam, air or hydraulic cylinders; represented by Fig. 3. Time (in-

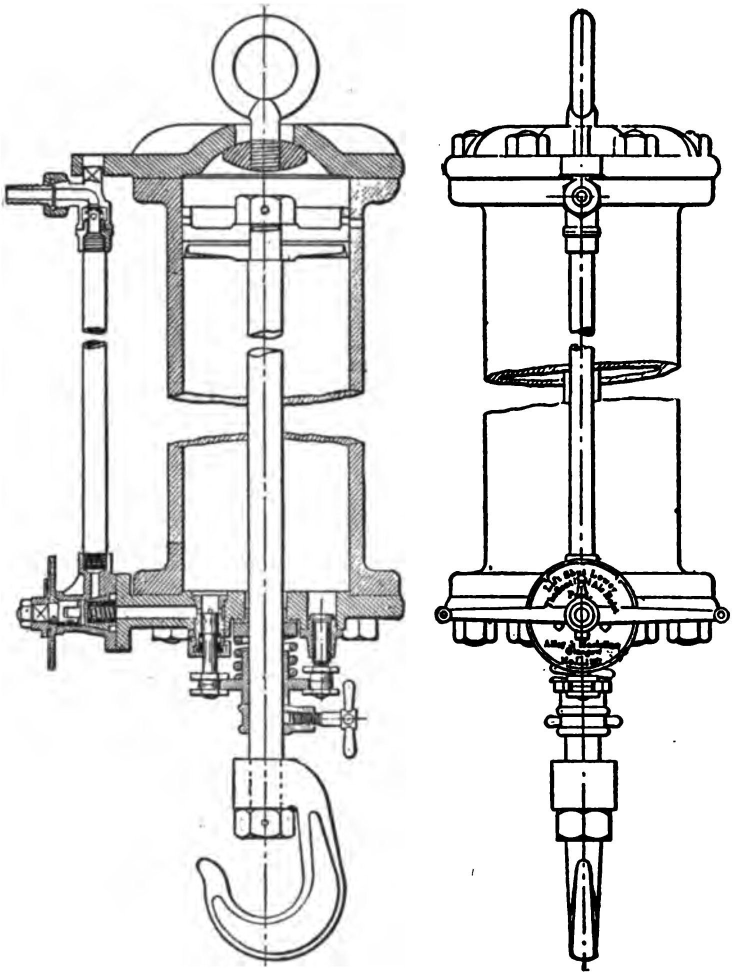

FIG. 3. Air Hoist. Assignment: Net Load, ... Pounds; Friction, ... Per cent.; Lift, ... Feet; Air Pressure, ... Pounds.

cluding one hour test or lecture each week), 20 hours.

(*f*) Sheet in kinematics. Original problem of a

bolt-heading machine or some form of wire-bending machine. Optional. Time (including one hour test or lecture each week), 12 to 24 hours.

9. Such a course as outlined above may be completed satisfactorily in 216 hours (36 weeks at 6 hours per week). If it is thought advisable *e* may

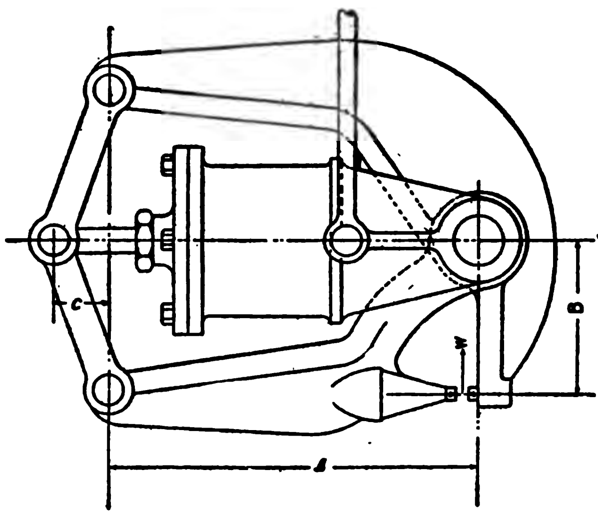

FIG. 4. Lever Riveter. Assignment: $A=(20'' \text{ to } 36'')\ldots.;\ B=(8'' \text{ to } 16'')\ldots.;\ C=(\frac{1}{2}'' \text{ to } 1\frac{1}{2}'')\ldots.;\ W=(25{,}000 \text{ to } 100{,}000)\ldots..$

be combined with *a* as in Fig. 4, or with *c* as in Fig. 5, in which case more time may be given to *f*.

10. *Working up the Assignments* (*a*), (*c*) and (*e*).—Assuming that the student has had sufficient instruction in the art of making drawings, then the stress of the instructors' work will be placed upon the following features: First, *the design;* this should be original as far as possible and should take into account adaptability of the machine to the work, sim-

plicity and compactness of parts, neatness of outline and cost of production; second, *the report of design;* this report should contain a diagram of the mechanism showing the resolution of the various forces, the calculations for the sizes of the members to sustain the forces, and such other important notes and

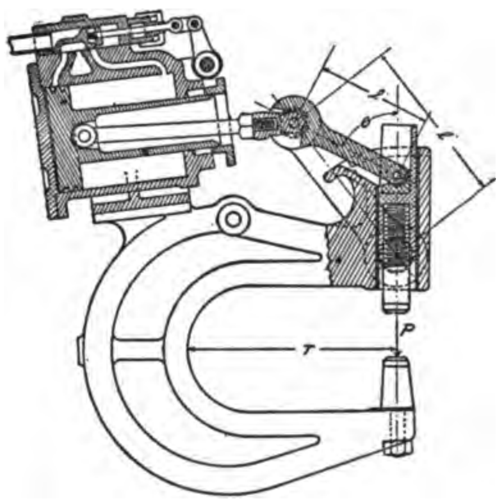

FIG. 5. Allen Riveter. Assignment: $P = (10{,}000 \text{ to } 50{,}000) \ldots\ldots;$ $T = (10\frac{1}{2}'' \text{ to } 66'') \ldots\ldots;$ $l = \ldots\ldots;$ $l' = \ldots\ldots;$ $\theta = \ldots\ldots;$ Air Pressure .... per Square Inch.

sketches as are not shown on the drawings; third, *the checker's report;* each student should have experience not only in planning and executing well his own work, but he should take up the designs of other men and offer suggestions and criticisms on their work. When the pencilled drawings are completed to the satisfaction of the one who made them, they are turned over to the instructor, who gives them to another student for checking. This checking is done in the form of

notes on a separate paper and attached to the drawings, after which they are returned to the designer, who makes such corrections and additions as he deems best and traces his drawings. Finally the tracings, drawings, report and checker's sheet are turned in to the instructor, who, after examination, gives credit to the designer for the design and the report, and to the checker for his suggestions and criticisms.

11. Kinematic sheets *b*, *d* and *f* may be worked up on a good grade of paper and need not be checked or traced. No report is necessary in such assignments.

12. *Observations as a Result of Such a Course.*— First, assignments should not be duplicated. A machine well adapted to the work may be made to serve for many assignments by varying the terms of the problem, as shown in Figs. 1, 3 and 5. Second, the type of machine should be varied from year to year; this should be done to keep any one machine from becoming commonplace. Third, lectures and references to standard authorities on machine design should be freely given. Fourth, a snap test should be given about once each week, lasting, say, one half hour. Fifth, the latest catalogs upon the subjects treated in the designs should be used to illustrate the best practice in shaping the parts and in outlining the machines.

Discussion.

Professor Benjamin: The term "machine design" is a very comprehensive one. We have found it necessary at Case School to differentiate kinematics and the construction of mechanism, in the class room, and to a certain extent in the drawing room. The-

mechanism is given in the first part of the junior year in the class room, and the kinematic problems are given in the drawing room, so the student is studying kinematics or the geometry of the machinery exclusively during that term. But he does not know at that time enough about the strength of materials to take up constructive mechanism. At the beginning of the second semester he has had the strength of materials, and he begins to study the construction of the machine, and the drawing is more of the character which Professor Hoffman has described, only that it is confined entirely to the construction part—the strength part rather than the kinematic side. I appreciate what Professor Hoffman has said with regard to the original problems. I have found it impossible with men at the end of the junior year, except in the case of some very brilliant student, to get anything like original designs from them; and we have confined ourselves very largely to working out the machine details. In the design of machine tools, one of the principal objects of design for the mechanical engineer, there is in many cases no possible way of determining before hand the stresses that will come on the machine. I have found it difficult in planning problems of this kind to get very far from this particular class of machines which Professor Hoffman has illustrated, in which you can assume a force to have a basis for calculation.

Dean Bissell: Mr. Hoffman's statement that he did not insist upon all men in the classroom working out the automatic machine problem struck a responsive cord in my experience. Years ago when I taught

machine drawing I did not go into automatic machinery. Later on, when I had an assistant in charge of the machine design I insisted upon his giving some work of that kind, and I nearly wrecked the department of machine design in insisting that the seniors hand in these problems. In connection with the other work, it occurs to me that it is a little more satisfactory to show a photograph or half tone or a good sketch so as to convey to the students a better idea of the machine than is given by a mere diagram.

Professor Wood: On the broad question of machine design, I do not presume to speak. I may call attention, however, to an advantage in having the general lay-out of the machines of special type taught by the one teaching the subject in the classroom and directing the tests in the laboratory. Take, for example, the design of a gas engine in the senior year: The whole principle of the design is so interwoven with the thermodynamics and the mechanics of the subject that it would fall naturally to the specialist who is keeping abreast with improvements to start the student in the general design. To be thorough, he must even go back to the chemistry of the gases. True, the student might go into the drafting room and apply a hundred or more empirical formulas, and some may call that design; but what has he when through with his work? The point I make applies to a greater or less degree to pumping and pneumatic machinery, to steam engines, including turbines, to refrigerating machinery and locomotives. It is hardly reasonable to believe the department of machine design would be able to cope with all sides of all these

questions, but by working in conjunction with that department the work can reach a standard of excellence hardly possible otherwise.

Professor Magruder: I believe it is well to teach mechanics as mechanics, and machine design as machine design; and not to teach machine design until the student has had a good stiff course in mechanics and mechanism, and completed his courses in shop-work and in drawing. When he is thus prepared by training in the machine shop and by experience in the laboratory, let him begin his work in elementary design by making free-hand sketches of parts,—such as a designer in the works would have a draftsman make for the shops. They should be made approximately to scale, neatly and accurately.

The distinction between a draftsman and a designer should be kept as sharp as possible. Five years in the drawing room, permits me to speak from experience. We do not usually put high-priced designers on elementary designs in engineering offices, but on original work where they can use their skill and ingenuity to advantage. The work in design should follow the work in theory and technology. It will go much smoother and take less total time. Much in certain college courses called by the name of machine design is but "detail drafting."

Professor J. D. Hoffman: In our college the descriptive geometry comes in the sophomore year; this work, with the sketching required of the freshmen in their free-hand drawing, possibly meets the suggestion of Professor Magruder. The kinematics and the mechanism are combined, and the constructive ma-

chine design occupies the greater part of our drawing-room time. The strength of materials and the mechanics of materials are taken as parallel subjects; we would prefer, of course, to have these precede the machine design, but as our curriculum is outlined we cannot do so. Concerning the assignment of work, I would not have you understand that these problems as given in the paper are now used; they merely represent typical problems and should be modified from year to year. Our method of assignment is usually to refer to some machine as given in a standard catalog, and after stating a few conditions, ask the student to design a machine after that general plan, making such detailed modifications as he prefers.

SOME EXAMINATION DATA.

BY R. D. BOHANNAN,
Professor of Mathematics, Ohio State University.

The freshman class in engineering at the Ohio State University takes college algebra the first term, plane trigonometry the second term, and analytical geometry the third term. The sophomores take a mild dose of both differential and integral calculus the first term, differential calculus the second, and integral calculus the third. Each class meets five times a week for fifty-five-minute recitations.

To each student at the beginning of each term printed lesson slips for the term are handed. These lesson slips designate the bookwork. In this way all men in any class have the same daily work and the same term's work, no matter who the instructor is. There were this last year twelve sections of freshmen and seven of sophomores, with an average of about twenty-five to a section. The lesson slips specify on what days the recitation hour will be turned into an examination. Four such "midterms" are given in each term. There is held at the end of each term a "final" examination, lasting four hours.

To determine a student's standing at the end of a term, his average standing in the four midterms is added to his standing in the final and the sum divided by two. The midterms are thus given the same weight as the final.

Examination papers are made out by an examina-

tion committee, consisting of three teachers. One man goes off this committee each year and a new man goes on. All sections of the same class reciting at the same hour are set the same paper. All sections have examinations on the same day and of about equal difficulty. Midterms for any section are graded by the instructor of that section, and the marked papers handed back to their authors as early as practicable. Frequently the paper is discussed at the next recitation following the examination. Appeals from markings are considered by the instructor or by the department secretary.

Final examinations are all graded by the examination committee and not by the instructor. The final mark for the term's work for a freshman is either "passed" or "failed." No "conditions" are given freshmen. Those who fail in algebra the first term may repeat the work the second term. Those who fail in trigonometry the second term may repeat it in the third term. Those who fail in analytical geometry in the third term may repeat it in the summer school, or the next fall term, or the next spring term.

By recent faculty action, no final examinations, at any other time than the regular recitation hour, may be set any class at the end of the winter term. This raised with us the question as to whether all finals might not be omitted and the average of our four midterms be taken as a fair test.

We examined all standings for the last two years. The result for last year was almost exactly the same as for this year, which is as follows for freshmen. The first pair of columns is what the finals would

have done for students in each of the twelve sections if we had trusted to midterms alone for the grades. The second pair of columns shows in the same way what the midterms would have done had we trusted to finals alone.

By finals. Fall Term.		By midterms. Fall Term.	
Helped.	Hurt.	Helped.	Hurt.
1	1	2	1
0	6	5	0
0	6	4	0
0	0	2	0
0	2	5	0
1	2	1	0
0	1	0	0
1	1	2	0
1	2	1	0
3	2	1	0
1	2	2	0
0	2	2	0
8	27	27	1

The men affected were, as a rule, "on the fence." The finals shifted 35 men, failing 27 who would have passed on midterms alone, and passing 8 who would have failed. Net loss, 9 men. If we had trusted to finals alone, 28 men would have shifted, 27 of them going from the passing side to the failing list. The number of men concerned was 273.

The winter and spring terms were as follows, the trailers being accidentally omitted from my notes at hand in the third term. There were three sections of them. The winter term relates to 256 men and the spring to 195.

By finals. Winter Term. Helped.	Hurt.	By midterms. Winter Term. Helped.	Hurt.
0	2	3	0
0	1	2	0
0	2	5	0
0	2	1	0
1	0	0	0
0	2	1	0
0	0	0	0
0	3	0	0
2	0	0	1
1	1	8	0
4	0	0	0
8	13	20	1

By finals. Spring Term. Helped.	Hurt.	By midterms. Spring Term. Helped.	Hurt.
0	1	4	0
2	1	0	0
1	4	0	0
1	0	3	0
1	1	1	0
7	1	0	0
2	1	1	0
4	1	1	0
1	0	0	0
19	10	10	0

SUMMARY.

	By finals. Helped.	Hurt.
Fall	8	27
Winter	8	13
Spring	19	10
	35	50

	By midterms. Helped.	Hurt.
Fall	27	1
Winter	20	1
Spring	10	0
	57	2

NUMBER OF MEN AFFECTED.

		Passed.	Failed.
Fall	273	200	73
Winter	254	219	35
Spring	195*	147	48
	722	566	156

Thus in 722 decisions, the effect of finals would have been to reverse 85 decisions that would have been made on midterms alone, with a net change of 15 men less in the passing list. If we had trusted to finals alone, the midterms would have reversed 59 decisions, passing 57 who would have failed.

What conclusion you draw from this depends on what view you have of the "man on the fence." With

* Trailers omitted.

us the man on the fence the first year is on the ground the second year. That we fail enough seems sure from the following: In the fall term, this year, in college algebra, of 273 men, 200 were passed, and 73 were failed, or 26.7 per cent. In the winter term, with 9 sections of regulars in trigonometry, and 2 of trailers in algebra, of 206 regulars, 176 were passed and 30 were failed. Of 48 trailers, 43 were passed and 5 were failed.

About 14.6 per cent. of the regulars failed, as against 26.7 per cent. in the fall. Only about 10 per cent. of the trailers failed.

In the spring term, with 9 sections of regulars in analytical geometry and 3 of trailers in trigonometry, of 195 regulars, 147 were passed and 48 were failed, or 24.6 per cent. Of 59 trailers, 43 were passed, 16 were failed, or 27.1 per cent., thus going back to the fall record of failures.

Both freshmen and sophomores do better in the winter than in the fall or spring, while losing about the same percentage in fall and spring.

It is sometimes maintained that lack of preparation in the high schools accounts for the large percentage of fall failures. We take freshmen and cut out about one fourth in the fall. Then from this selected lot about one eighth in the winter, and from this second selected lot another one fourth in the spring.

We treat sophomores in almost identically the same way. This year in the fall we had 178 sophomores, passed 127, conditioned 35, and failed 16, or a total loss of 28.6 per cent. In winter, with 151 regulars and 26 trailers, we passed 137 regulars and 21 trail-

ers, losing of regulars 9.3 per cent., and of the total 10.7 per cent. In spring, with 136 regulars and 24 trailers, we passed 98 regulars and 20 trailers, losing of regulars 27.9 per cent., and of all 26.3 per cent. Weather affects both classes. All do better in winter, and about the same in the fall and spring. Of 178 sophomores who started in the fall, only 98 completed the year's work, or a loss of 45 per cent.

Of 301 freshmen, made up of 273 regulars of the fall, and the rest trailers of the former year, we passed 147 on the full year's work, or a loss of 51.1 per cent.

The great value of the trailer sections is shown. By their aid, of 273 in college algebra, 243 passed. Loss, 11 per cent. Of 265 in trigonometry, 219 passed. Loss, 17.4 per cent.

Men of best mathematical talent do better on finals than the average of their midterms. Middle men do better on midterms than on finals.

Some men, generally those of small mathematical ability, get a high average on midterms and drop very low in finals. The holding of finals is a matter of indifference for the upper half of the class. It hurts the men on the fence very materially.

(For discussion, see page 609.)

THE TECHNICAL AND PEDAGOGIC VALUES OF EXAMINATIONS.

BY HENRY H. NORRIS,
Professor of Electrical Engineering, Cornell University.

The examination has long been the bane of teachers and students and is still one of the most trying features of educational work. Many methods of conducting examinations are in vogue, the underlying principles as well as the details depending largely upon the personality of the instructors in charge. In analyzing the value of examinations under the two general heads, technical and pedagogic, the following points appear to be most prominent:

Technical Value.—From the practical standpoint the examination can show two conditions in the student's mind: (*a*) His memory for facts; (*b*) his engineering judgment. The writer believes that the first of these is of very little value, while the second is most important. In the senior classes in Sibley College for the past year the examinations have been conducted with the idea of exhibiting the judgment of the students rather than their memory. Topics of a general nature have been assigned and the students requested to give a perspective view of the subject in a limited number of words. The result has been very interesting and on the whole profitable. Many of the students regarded the examinations as easy, while as a matter of fact the best students found them more difficult than those which test primarily the memory.

As examples of these topics the following will serve.

The rise of pressure in transmission lines. 200 words.

Conditions governing the design of transmission lines. 200 words.

Losses in transmission lines. 200 words.

Losses in transformers. 150 words.

Pressure regulation in transformers. 150 words.

Magnetizing and exciting current in transformers. 100 words.

Explain the operation of the induction motor to a person not familiar with mathematics. Show him why the secondary rotates at a definite speed and how torque is produced. Assume that he understands the action of the static transformer. 250 words.

Discuss the physical facts connected with commutation and their bearing upon electrical practice. 250 words.

Discuss the physical facts underlying the operation of the rotary converter and show their bearing upon electrical practice. 250 words.

Discuss the open coil arc machine and its relation to standard electrical practice. 250 words.

Explain without the use of diagrams why the power-factor of the load upon a transformer affects its regulation. No word limit.

What is the present status of methods for predicting the regulation of alternaters under loads of variable power-factor? No word limit.

What are the difficulties in the way of successful commutation? No word limit.

None of the above topics can be intelligently dis-

cussed without a general knowledge of the subject, although the first tendency of the student is to appeal to his memory for his answers. Incidentally the discussion upon these topics brings out the ability of the students to express themselves in clear language. This is a most important part of the exercises and the students are impressed with the importance of attention to it.

The fact that an examination is expected at a definite time serves as a stimulus to study, but such study is intermittent and superficial. It is apt to be concentrated in a few days or a few hours before the time of the examination if such time has been advertised. It has been found desirable at Sibley College to abolish examinations at the end of the term and to give only so-called "preliminary" examinations, usually about once per month. These examinations or written reviews are less formal than the final examinations and their more frequent occurrence tends toward uniformity of effect.

The technical value of examinations resolves itself into the effect upon the training of judgment or *engineering perspective* (which is most important) and the stimulus to study and reflection.

Pedagogic Value.—The pedagogic value of examinations cannot be entirely separated from the technical. The important feature from this standpoint is the necessity of having some method of gaging the progress of the students in the particular subject under study. Such progress is not to be judged by the number of facts which the student is able to marshall at a moment's notice, for it is generally conceded

that the student with the best memory is not always the most thoroughly equipped for practical life. In fact the writer is inclined to believe that the excessive use of memory tends to superficial study. If a student thoroughly understands a subject he can exhibit his knowledge in the discussion of very simple topics as outlined above.

Another pedagogic feature which has been already referred to is the stimulus to study and review. From the students' standpoint this is desirable, as with the present constitution of human nature it is difficult to rely entirely upon interest for such stimulus. Frequent class recitations are ideal for the purpose, but even in this case occasional more formal examinations are desirable. With lecture courses they are essential.

The objections to examinations, in which all teachers share, result from the dependence of the students upon their memory in discussing topics. If such memory tests could be entirely eliminated there would be no possible objection to examinations. The difficulty lies in eliminating or minimizing the effect of the memory. Obviously the memory must supply the raw material from which "briefs" may be prepared at short notice, but the raw material in its crude form is not what the teacher desires in the answer to an examination question. It has been suggested that examinations be "sprung" upon the students without notice, but in the opinion of the writer this practice is objectionable. The student should be liable to review questions at any time, but in order to prepare himself for a written review he needs to digest the

material he has absorbed more carefully than is possible from day to day. He must wait until a topic is complete before he can grasp the relation of all of its parts, and this in many cases requires several weeks of lectures or recitations. The number and frequency of these written reviews depend upon the rate at which the work is given, but in general not more than five to ten lectures or recitations should occur between reviews.

In conclusion the writer believes that the most important advantage connected with examinations is the exercise in expression, requiring perspective and judgment in the minds of the students.

Joint Discussion.

Professor Jacoby: A year or two ago an engineer in practice said to me: "Why do you not give examinations to your students by allowing them to use their books, because that is the form in which we are obliged to pass examinations in practice?" I tried it in one class, but found that the books were a hindrance, the students doing less work than was formerly the custom. I would like to know whether any one has had a similar experience. My own practice has been recently to give fewer final examinations and more preliminary examinations during the term, and with satisfactory results.

Professor Benjamin: In reference to what Professor Jacoby has said concerning the use of the book, I would say it has been my custom for quite a number of years to use the book or not, according as the subject made it appropriate. In our machine design and

kinematic designs the book is used in most examinations. We usually do not tell the men before going to the room whether we shall have books or not. Experience has led me to believe that examinations with the use of the books are very valuable. With reference to the final examination, I believe it is less important than the test or quiz. We are in the habit of giving examinations and tests every two weeks. If a man has 30 or 50 on a test, that is his last chance. At the end of the term, if his term average in his recitations warrants it, he is excused from the examination. Otherwise we give the final, and that is averaged with his term average on some equitable basis. In case he does not come up to a certain standard, another final is given at a suitable time, and that is averaged in with his other grades. In other words, he has to leaven the whole lump. I have found it very satisfactory to have the young men understand when they come in for a test or examination that that is their only chance; that if one gets a low grade there is no help for him, but he can bring up his grade by subsequent good work.

Professor Brackett: If the students knew that the use of reference books was to be permitted, they may have neglected the usual preparation for the examination; and that fact may account for their poor showing, as was suggested by Professor Benjamin. However much cramming for examinations may be condemned, it is possible for a student to make, in a very short time, a comprehensive review of most subjects. It is also possible for such reviews to contribute much to the student's general grasp of the

subject and the proper correlation of its parts. The regular type of examination without helps of any kind is, in my opinion, valuable as an incentive to such review work.

Professor Jacoby: The men did not know that they were to use the books until the day before the morning of the examination. They therefore made presumably the same preparation as for an examination without the use of the textbook. I would like to ask Professor Benjamin about the provision for giving a later examination to students that failed.

Professor Benjamin: They are granted a reexamination from a month to two or three months later. Some men stand high on the examination without the book, while other men stand very much higher with the book because they have poor memories. For my own part, I prefer the men that get along best with the book.

Professor Magruder: I cannot agree with Professor Jacoby. I think he took snap judgment on his class. What did they study the book for? Was it simply for mental exercise or to learn engineering principles and information? Do you ever expect the students to use that book again? There are certain things like the multiplication table which we should get into our heads to keep there for future reference. But there are some things we do not want the student to cram into his head. There are certain things that the student ought to learn and know, and there are other facts and data concerning which the student ought to know only where he can find them recorded. I think it is a good scheme to give the examination

in two kinds—of things the student ought to know and carry with him, and of his ability to use the text- and reference books. After he has handed in his paper on the first portion, give him an examination on the remaining portion, and let him use any book he sees fit. Does he know where to find things? Can he use them after he has found them? Does he know how to use the tables of squares, and square roots, and reciprocals, and the like? That is the way engineers do in practice. We have not time to figure it all out by arithmetic. If the student cannot use his hand-book intelligently and accurately, I feel sorry for him.

Professor Norris's paper brings out another question. I once gave an examination in the subject of power plants. I said, "state the kind and location of machinery you would advise using in a power plant of a thousand horse-power capacity to be installed on this campus to generate electricity, and give your reasons therefore." Such an examination for students who have been on the campus for three years, brings out the question of both their knowledge and their judgment. It includes many questions such as, would you use condensing engines or non-condensing engines? Vertical or horizontal? Chimney draft or forced draft? That brings out, in my judgment, the knowledge that a student has on that subject. I think there is a distinct pedagogic advantage in training a man's judgment.

President Howe: The two papers which have just been read seem to supplement each other. One paper takes up the effect on the student's mind without going into the value of the examination; and the other

paper is a discussion of the value of the examination to the student. I have always believed in final examinations because if the student does not have the final examination but is simply given a number of tests, I think he studies the subject in parts. He believes when he has passed a test upon a small part of the subject, that he has finished that, so far as any requirement of the college is concerned. But in his final examination, he brings all parts of the subject together, and this, I believe, to be a most vital thing,—to see that the student carries the whole in his mind, that he is master of the subject. If we do away with final examinations, it seems to me we are lowering our standard. Our students feel that a very hard and difficult part of the work for them has been taken away, and the whole subject is very much easier. I am looking at this from the student's standpoint. He does not acquire a thorough knowledge of the subject if he is not obliged to review it for final examination.

With regard to books in examination there are certain subjects the student ought to know, and there are parts which he should take up in the way in which he will take them up in after-life. A man given an examination on the theoretical part of trigonometry should not use a textbook. But when he has to solve a problem, he needs a table of logarithms. So with the calculus. When it comes to the practical problems where long integrals are brought in, we allow him to use a table of integrals in the examination just as he would use it in the solution of problems in practical work.

DEAN KENT: People object to the examinations on account of the mental strain they put on the students. That is what I have seen in public print, but I have not heard it in these discussions. Sometimes I use the premium system. I announce before the examination that I will excuse them from the examination if they will do tip-top work, and to those that do not, I will give examinations, and those that do not pass the examinations will have to take supplementaries. I tell them that our business is to give them an education, even if it takes more than one examination to get it, and a special examination costs five dollars extra.

PROFESSOR MAGRUDER: I am opposed to the system of excusing men from examination. I do not think there is a more abominable practice in vogue in the public school system of this state. The pedagogic value of the mental training and experience to be obtained by the student from an examination is totally ignored. The life of the engineer, of the professional man, of the business man, is full of examinations. Clients and customers seldom give notice that they will call at such an hour on such a day and ask us in advance to be ready. They spring examinations on us without warning. Such is life. Now what is the training that our children receive in the grammar school, high school and college? In effect, "if you will make good daily recitations, 'if you will do tip-top work,' as Dean Kent expresses it, you will be excused from the examination." In other words, "if you will put down correctly the daily items in the monthly statement of the account, you need not

add them up and determine the amount. If you will run up the walls, jambs, and voussoirs of the arch, and lay the stones skillfully, you will be excused from setting the keystone." Now what is the result of the system? To have to take an examination in the grammar school or high school is considered a misfortune, even if not a positive disgrace. Scholars and parents resent it. It is easier for the teacher to omit the examination. Ease and popularity are gained. And so the young man, or woman, comes to the university. Never having been trained to answer questions in writing, or to condense his spoken words into terse language, or to work continuously for from two to four hours on one subject and in one place, as he will later be required to do in office work, he naturally finds the mental strain severe. Complaint is made of the arduousness of university work and the examinations, whereas the truth is the trouble is in the unpreparedness of the student due to his lack of proper training. An athletic director might as well train a man for the hundred-yard dash as a preparation for a mile-run as to expect the mental training given by a short, oral recitation to answer for that required for a long, written examination.

I am pleading for the proper training of the student, and not for the professor. With a small class which has recited frequently, the teacher should not need to examine a student to determine his grade. With large classes whose units recite only occasionally, the instructor may rightfully need the information to be gained from the examination papers. I greatly deprecate the practice of allowing examinations to take the

place of frequent quizzes. Such is one of the objections to the lecture-system of instruction.

Having studied the pages assigned for the day's recitation, and obtained a microscopic image of a small portion of the subject, the student should then be required to recite on a larger portion, say one quarter, or one third of the term's work, so as to get a more general picture of a part of the subject, and lastly he should be granted the opportunity and privilege of testing his knowledge of the subject and of the work of the entire term by a final review and examination, so as to permit him to get the larger landscape into view, and see the relation of the integral parts to the whole subject and to surrounding objects. Frequent recitations from each individual of a class, then the review lessons, and lastly the final examination; such, I claim, gives the best training for the daily work of the engineer and professional man.

Professor Higbee: While in college I talked the matter of textbooks over with my class. We felt it made no difference whether we used textbooks in examinations or not. If we did not learn our lessons, the examinations could not be passed. When we studied our lessons, we were using the textbook only as a tool or reference. We all felt that examinations were not a bug-bear, they were a real test of our ability. We were glad to take examinations to see what we were able to do.

Professor Benjamin: There is one point, it seems to me, that has not been brought out in this discussion. My idea in holding tests and examinations is to find

out for my own personal benefit what a student knows on a subject. In conducting examinations, I conduct them with that end in view. If a student derives any benefit from the examination, I am very glad to know of that fact. As to excusing them from examination, it has been my custom when a man has obtained a certain rank in his tests and daily grades, to excuse him from final examination. Such men simply do not need the examination. I do not need to examine them, and without any reference to their feeling in the matter, I excuse them from examinations because it is an unnecessary process. I already know all I want to know, and the examination would make no difference.

Dean Kent: That is my case exactly.

Professor D. C. Jackson [Secretary in the chair]: My view of the examination is the opposite of Professor Benjamin's. I do not feel that I need to hold an examination to learn whether the students should be failed or passed, or given a medium mark or a good mark. I want to give a man a hard examination—not hard from the standpoint of memory, but because it makes him work with great concentration for several hours,—with the idea that one part of an engineering student's equipment is ability to meet conditions of emergency. I am generally willing to have a student go out of the examination room to the library and study anything that will help him in that particular case. He is better able to meet the emergencies of every-day engineering life if he has gone through six or eight drills of that kind during his junior and senior years. From that point of view.

examinations are decided pedagogic aids in engineering courses. Perhaps they are not needed in the lower grades. Professor Kent says he never heard until recently that examinations were too great a strain on the intellect. If you will go back several years in our proceedings you will find that there have been numerous discussions on that subject. But apparently we all think now that examinations are good things, though we do not all hold the same reasons for our beliefs.

DESCRIPTIVE GEOMETRY—ITS IMPORTANCE IN THE ENGINEERING CURRICULUM AND THE METHODS OF TEACHING IT.

BY OTIS E. RANDALL,
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Since projection has been universally adopted as the medium of graphic representation, and since this medium is so extensively used in engineering practice, everyone admits that the student of engineering should in some way or other acquire a working knowledge of the fundamental principles of the system. But whether the study of pure descriptive geometry, which of course deals with the fundamental principles of projection, is absolutely necessary or at least worthy of the assignment of so much space as is usually given in engineering curricula, and what are the best methods of treating the subject, are questions upon which there are differences of opinion.

The direct or apparent results of the study of descriptive geometry, the ability to intelligently and skilfully use the various forms of projection in the representation of magnitudes of great complexity, is only one of the advantages derived from such study. The unique and vital part which the study of descriptive geometry plays in the development of the mind is the one thing which makes the subject of such importance in the engineering curriculum.

There is a tendency in the modern engineering schools to lay stress upon those courses which are

practical in nature, which supply the student with needed information, but without requiring mental effort or resulting in mental development. We are inclined to forget that intellectual development is the prerequisite of breadth of vision, depth of insight, and soundness of judgment, qualifications without which a man will make poor use of the best of opportunities.

The nature of the material with which the subject deals and the character of the medium through which the subject is approached and treated, a medium which differs radically from the usual pictorial method of representation and which requires the simultaneous observation from a number of standpoints of magnitudes and the operations performed upon them, calls for a form of mental exercise whose value is seldom appreciated.

The study of descriptive geometry greatly increases the power of comprehensive thinking. The power of concentrating the thoughts upon a single matter to the exclusion of all others is of great value and is rightly regarded as a sufficient reward for years of study. But this power is often acquired at the sacrifice of another equally rare and sometimes more valuable power, the power of simultaneous consideration, comparison, and combination of the numerous parts of which a whole may be composed.

These parts are frequently so closely related that it is not safe to consider any one apart from the others. Of course our system of projection enables us to place upon a single sheet many views of the same object and through this medium to comprehend

at a glance the nature relation and combination of the various parts which make up the whole, but frequently in the field of design, before the design has reached the stage where it can be represented on paper, or even in model, the mind is called upon to consider simultaneously the details of a large assemblage of parts. The importance of this power in the realm of thought is not confined to the field of engineering but should be recognized in all branches of analytic and synthetic work. Is there any subject the study of which can do more toward the development of this altogether too uncommon power than descriptive geometry? Many men to-day who use this power with so much freedom and find it such a valuable possession, little know how much they owe to the study of descriptive geometry. The practical results of such study, valuable as they may be, are small in importance when compared with the subtle influence which the oft-repeated and still fruitless efforts to understand had upon the development of the mind.

The classroom work connected with the study of descriptive geometry, when properly conducted, furnishes unique practice and dicipline in vocal expression of thought. Practice in word expression of ideas which are easily and definitely formed in one's own mind and which are more or less understood by others, is of daily occurrence, but practice which comes from the attempt to express in correct and intelligible language that which is intangible and difficult of expression is uncommon but most valuable.

The real worth of the study of descriptive geometry depends very largely upon the way in which the

subject is taught. If the student is simply to sketch upon paper and in a conventional way the various views which he may obtain of an object from a number of standpoints, he will acquire little more than a very convenient method of representation, the value of which is comparable with any manual skill which comes from years of practice, and which is not an expression of intellectual effort. If this is all we wish to secure from such study, the student would do better to omit the courses in solid and projective geometry and enter at once upon the work of machine drawing, as is frequently done, or better still go directly to the drafting room of the manufacturer. But statistics show that men of this training seldom rise above the subordinate's position. They soon reach the point where the undeveloped and unimaginative mind fails to supply the material for future growth.

Concerning the best method of treating the subject, it would be impossible to formulate a universally applicable method of procedure owing to the widely differing circumstances under which the subject must be taught. The writer simply offers the following suggestions which are based upon his experience for the last twenty years.

The preliminary training of the student of descriptive geometry should include thorough courses in plane and solid geometry, elementary mechanical drawing, and freehand drawing. A knowledge of plane and solid analytic geometry is very desirable but owing to the fact that descriptive geometry must come early in the college course it will rarely happen

that the student will be able to meet this requirement.

The mastery of many branches of engineering science is made much more difficult and laborious by the want of a working knowledge of mathematics. It is as absurd to attempt to teach descriptive geometry without the aid of solid geometry as to teach mechanics without the aid of the calculus.

The preliminary training in mechanical drawing should be confined to plane problem work as any exercise in projection calls for the use of the very principles which the study of descriptive geometry is intended to establish and which if the student uses at this stage he must use in blind obedience to conventional methods. A student should never be encouraged to follow blindly the direction of anyone or to employ methods or principles which are beyond his understanding, tendencies which are altogether too common in preparatory schools and colleges. During the period of intellectual development the mere acquisition of knowledge is of small importance compared with the process by which it is acquired. It is an insult and an abuse of the intellect to act independently of its judgment.

The training in mechanical drawing should be extensive enough to enable the student to use all the drafting instruments with intelligence, with facility, and with accuracy. Considerable time should be given to clean and precise penciling with extensive practice in pin-point work.

The study of descriptive geometry should open with an exhaustive discussion of the theory of projection, and nothing further should be attempted until

this has been accomplished. The student should thoroughly understand at the outset the meaning and relation of point of sight, and planes of projection, remembering that projecting lines are always visual rays. He should be given sufficient practice in determining the projections of simple magnitudes under the varying relations which may exist between point of sight, plane of projection, and magnitude to enable him to read easily through the medium of projection the characteristics of position and direction.

The point and straight line as magnitudes are quite sufficient for this work but he should have practice in determining the projections of these magnitudes from all standpoints, and in reading their characteristics from a simultaneous observation of a number of projections. By the use of the same simple magnitudes the student should be taught the meaning of revolution, and by extensive practice he should be made familiar with the methods of representing by projection the process and result of revolution about axes in a variety of positions.

There is little danger of giving too much time to these preliminary notions. It is neglect at this very point on the part of the instructor which makes the study of the subject as a whole difficult, meaningless, and sometimes well-nigh useless.

When the student has become familiar with the representation of the point and the problems relating to it, it becomes very easy to take up the problems relative to the line which is the generation of the point. In the same way the student passes easily from the problems of the line to the problems of the

surface which is the generation of the line, and finally from the problems of the surface to the problems of the solid which is the generation of the surface.

Stress should always be laid upon the generation of the various magnitudes. There is no other way by which the student can become more familiar with the characteristics of an object than by learning how it is made, and when he finds that it is made up of parts with which he is familiar he is in a position to understand thoroughly what so often prove to be complex features of the combination.

In establishing the fundamental principles of the subject, use should be made of the most elementary media, otherwise the principles will be lost sight of in the effort to understand the medium, or very frequently in the interest which is aroused by an attractive medium. The student should be taught that it is not the solution of a large number of assigned problems which is important, but the establishment upon a working basis of a large number of principles of general application. During the earlier stages of the work there is little danger of being too explicit, but as the student begins to master the principles one by one he should receive less and less assistance until at last he should be required to make a great variety of simple applications depending solely upon his own resourses.

As by far the greater part of practical drafting is done from the standpoint of the third quadrant, there seems to be no good reason why the principles of descriptive geometry, which are so directly and extensively applied in practice, should not also be pre-

sented from the standpoint of the same quadrant. The student should be called upon to work freely in all the four quadrants, but the subject matter should be presented primarily from the third quadrant.

Not less than one full year of four hours per week should be devoted to the subject of pure descriptive geometry and its applications. The work should be divided into three parts: (1) Recitation work, (2) precise plate work, and (3) approximate plate work. Recitation work should be largely blackboard work, done by the student and without the aid of the book. Diagrams should be constructed with care, observing so far as possible the rules adopted in connection with notation. On the completion of the diagram the student should be called upon to state the problem, to analyze the method of procedure, and to explain the construction. With a good textbook the instructor should be expected to do little more than to encourage and direct discussion, making sure that no false notions pass by unobserved.

The use of models in connection with explanations, except in rare instances, is not to be encouraged, since to understand through the medium of the model removes the very mental exercise which makes the study of the subject so valuable.

The precise plate work, which is intended to encourage accuracy and finish of workmanship, should be done in the drafting room and under the guidance of a competent instructor. Problems of definite layouts differing from those taken up in the classroom yet calling into use the same principles, should be assigned to the different students. The student

should be required to construct these problems first in fine pencil lines and with great care. He should check the work by some approved method and indicate by some sign the notation to be observed in inking, differentiating between visible and invisible parts, also between given, required and auxiliary parts of a problem. When the work in pencil has been completed and approved by the instructor the plate should be finished in ink and handed in for final examination. If such plates are not perfectly satisfactory a reconstruction should be required.

The approximate plate work in which no great degree of accuracy is required is intended to supplement the theoretical work of the classroom. This work should be constructed upon faintly lined cross-section paper and may be done in pencil with the aid of the two triangles and compass.

As the principles of projection are fundamental in all branches of drafting, it follows that no attempt at extensive application of these principles in such subjects as machine drawing, gearing, architectural drawing, etc., should be made until the principles themselves have been thoroughly established.

The course in descriptive geometry should not be regarded as complete without giving some instruction in isometric projection and other forms of one-plane projection; also in shades and shadows, and perspective, treating these subjects as applications of descriptive geometry. Even though a student may never be called upon to make use of these branches of drafting, which is rarely true, their study as direct applications of descriptive geometry is not only a most valuable

training, but also a very acceptable medium through which to make clear the applicability of the principles of descriptive geometry.

DISCUSSION.

DEAN FULLER: At the University of Washington, descriptive geometry, including drawing, has been considered as one of the most difficult and at the same time one of the most important subjects to present in a satisfactory manner. The importance is considered to lie not only in the "mental exercise which results in breadth of vision, depth of insight and soundness of judgment," as stated by the author, but also in the opportunity and desirability of introducing the student at the beginning of his course into an engineering atmosphere, and making apparent to him the practical usefulness as well as the cultural value of this subject, the desirability of which as required work in the engineering courses is so often questioned.

As this course is the first in which the student meets any of the engineering faculty, we consider that the general strength and personality of that instructor has a marked influence upon the subsequent work and, indeed, the future career of the embryo engineer. An effort is made at this time to interest him not only in the particular course, but in engineering work and in engineers in general, by occasional short talks, and by passing around well-written papers such as Waddell's "The Relation of Civil Engineering to other Branches of Science." These have been eagerly read by a large proportion of the classes.

The author well implies that projection work should not be given in advance of the principles of descriptive geometry. His statement, also admitted by the writer, that it should all be preceded by training in elementary drawing, suggests an arrangement of work which may, under some conditions, lead to an awkward schedule.

It has seemed desirable with us to make descriptive geometry a freshman subject. It has been impossible to secure satisfactory preparatory drawing from more than a small proportion of the fitting schools. We have, therefore, been endeavoring, and I believe with an increasing degree of success, to teach the fundamental principles and the execution of descriptive geometry and drawing (including lettering) in a four-hour course for a year—two recitations and two drawing periods per week.

There has been some difficulty in securing a strictly satisfactory adjustment between the recitation and the laboratory work, both in regard to the amount of time and the sequence. The readiness with which the average student will analyze an original problem of either theoretic or practical nature toward the end of the year, and the satisfactory character of his execution gives us encouragement to continue development along present lines. Shades, shadows and perspective are not included in this course.

Dean Kent: In our college, we had descriptive geometry taught in the same way, three hours a week for a year, and it was considered the most difficult and troublesome subject we had in the whole course. In order to simplify it, we cut it out from the first

semester entirely and gave them just half as much descriptive geometry. That was going in opposition to the principle laid down here, which says that "the preliminary training in mechanical drawing should be confined to plane problem work, as any exercise in projection calls for the use of the very principles which descriptive geometry is intended to establish." We taught mechanical drawing, and gave them three views in the way that the ordinary draftsman gets it. We taught it as drawing, but they were getting descriptive geometry all the time in the first semester without knowing it. We find a great advantage in doing that. There have been fewer failures in the second semester in descriptive geometry than before, and everybody is well pleased.

I do not know whether any one else tries it that way or not. I never heard of descriptive geometry for years after I had been doing mechanical drawing. The word seems to have been invented to puzzle students and to confuse their brains. The student is told that the line should be regarded as the generation of the point, the surface as the generation of the line, and the solid as the generation of the surface, whereas for years they have taken the point as position without magnitude, the line as length without breadth, and the solid as a solid body. This mathematical conception of descriptive geometry is very well postponed until the second semester of the freshman year, when their brains are more mature.

Professor Williston: I am glad to know that Professor Kent is teaching mathematical drawing in such a practical way. The author of this paper has made

absolutely clear that descriptive geometry is the most magnificent mental training that can be had. Earlier in the week it was brought to our attention that Greek was the very best possible abstract mental training that a young man could have. I would, therefore, suggest that Greek be substituted for descriptive geometry wherever the latter occurs in any of our engineering courses, as I believe that the Greek will be found to have the greater practical value of the two in after life!

In our engineering courses Greek has another great advantage over descriptive geometry. It is not nearly as easy to get passing mark in Greek without knowing something about it as it is in descriptive geometry.

Professor Benjamin: I am interested in what Dean Kent said about his drawing so many years before he studied descriptive geometry. I had the same experience. I was a machinist and draftsman before I went to college. I had been making projection drawings and intersections. It was all perfectly reasonable to me. When I came to college and studied descriptive geometry I was surprised to see how difficult a subject it was.

President Howe: Our course is slightly different from that outlined by Dean Kent. We give the mechanical drawing and descriptive geometry in the freshman year, but we use the individual system. Every man demonstrates every proposition. In the second term, the work in descriptive geometry consists in original problems which are assigned and worked out in the drafting room. A man is given

three hours to work the problem, and these exercises in descriptive geometry are the exercises in drafting. We find no difficulty in having our men do the recitation work. A man is given the opportunity for recitation, and he may recite until he stumbles. If he stumbles at the beginning he stops and must study before reciting again. If he can recite five propositions, he may do so; but if he shows that he does not know the lesson, he stops.

Professor Higbee: I have given instruction in descriptive geometry in the way Dr. Howe has described; since I have been in Iowa I have been giving drawing first, but after trying it for two years I am going back to giving descriptive geometry first. I believe that the name is a bugbear. Call it what you please—top view, side view, plan view, but give us descriptive geometry. If it is taught right the student can get projection. I think it should come first, so that the student may apply it to mechanical drawing. He will do better in his drawing and he will do his descriptive geometry just as well.

Professor J. D. Hoffman: At Purdue we start the first year with mechanical drawing, and this is carried throughout the year. In the sophomore year we take up descriptive geometry.

Professor Magruder: Are not many of us worshippers of a fetish?

Professor Kent: The reason I had such an antipathy against descriptive geometry was because I had such a time with my boy when he was in Stevens Institute. I said: "What is the use? What is it all going to lead to? It is too much time to spend on

that kind of a subject. If ever I have anything to do with it, I will boil it down." And when I got to Syracuse, I boiled it down.

PROFESSOR HIGBEE: I think that is the trouble with descriptive geometry. It is taught as mathematics. But if you apply it and give them practical problems, it becomes as interesting as a romance. Teach them only theory and it becomes a bugbear.

PROFESSOR BENJAMIN: I thought it was mechanical drawing before I went to college, and I think Professor Higbee is right. The real trouble with descriptive geometry is you are required to imagine a lot of things that are not so. If you start with a concrete object, something that you see and feel, you will not have any such trouble. This idea of imaginary planes and surfaces is uncalled for.

PROFESSOR MAGRUDER: If a man has had only mechanical drawing and has to get out the detail drawings for the stones for an arch, or the sheets of a bustle-pipe, do you think he could do it with only the projection drawing such as it is taught to the draftsman in the drafting room of an engineering works? Would he not need a little more training in descriptive geometry?

PROFESSOR BENJAMIN: I do not think I could do it in any way.

PROFESSOR JACOBY: How many students can an instructor hear in one hour?

PROFESSOR HIGBEE: Students were supposed to come to us after they had prepared their lessons thoroughly. If a student made a blunder that showed that he did not know the problem, he was dismissed

and his name was crossed off. In that way the men came pretty well prepared, and the number of men one could hear in an hour depended upon the number of problems they had prepared. I should say that the recitation of each problem would last five minutes; a class of fifty men should have two instructors.

THE HONOR SYSTEM OF EXAMINATIONS.

By WM. H. SCHUERMAN,
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Vanderbilt University.

This system is in quite general use in southern colleges, but the writer is personally familiar only with the methods at Vanderbilt University of conducting examinations and of proceeding in cases of detected or suspected fraud under this system. However, at the Twelfth Annual Meeting of the Association of Colleges and Preparatory Schools of the Southern States, held at Knoxville, Tenn., November 1–2, 1906, a paper was presented by Professor W. M. Thornton, of the University of Virginia, on "The Honor System at the University of Virginia in Origin and Use," from which paper, as published in the Proceedings of the Association, extracts will be made to form Appendix II. of this paper.

The honor system has been in use in Vanderbilt University since the opening of the academic department in 1875. The regulations governing examinations in force at present are:

"No book or paper shall be brought into the room, except as prescribed by the examining officer.

"No communication of any kind shall be had by students with each other during examination, nor shall any student not under examination be admitted to the room without the consent of the examining officer.

"No student shall leave the room during his ex-

amination, except in case of necessity, and with the consent of the examining officer, and no absence shall be longer than ten minutes.

"The plea of sickness shall not excuse a student for failure on examination, and no student may leave the examination room on account of sickness, without the consent of the officer in charge, which consent will entitle the student to another examination.

"No student will be admitted to an examination more than fifteen minutes after the opening of the examination without a satisfactory excuse; and a tardiness of one hour shall be counted as an absence, and shall forfeit the right to an examination altogether.

"No paper will be read which does not have the following pledge, signed by the writer: 'I hereby pledge my word of honor as a gentleman that in this examination on ——— I have neither given nor received assistance; the paper herein recorded was written in full compliance with the letter and spirit of the Honor System.

——— ———.'"

In addition to the blank pledge, given above, to be filled in and signed by the student, there is printed on the first page of the official booklet used in examinations, the following:

HONOR SYSTEM.

"All examinations are conducted under the Honor System. Students are under pledge neither to give nor receive assistance; they demand that this pledge be faithfully kept by all. To this end they agree to

report to the Students' Honor Committee any real or apparent violation of the spirit or letter of this law."

For a good many years, the form of the pledge was the following:

"I hereby pledge my honor that I have not given or received assistance during this examination." This had to be written out by the student himself and signed; but it was found by experience that students would abbreviate or change the form, usually in all innocence, but very rarely with the intention on the part of the student of putting the pledge in such a form that he could persuade himself that he had not violated the letter of his pledge even though he had violated the spirit of the system. Of course it was assumed that papers having on them pledges at variance in form with that prescribed should be thrown out and the students handing them in marked zero on the examination. All, whose duty it is to observe the enforcement by individual members of rules adopted by a faculty, know that such enforcement varies from that of a strict constructionist to whom the alteration of a single unimportant word is sufficient to throw out a paper, to that of a liberal constructionist who will accept any kind of a pledge as sufficient. The writer has known the single word "Pledge" with the student's signature thereto, accepted as sufficient. As evidenced by discussions in faculty meetings at Vanderbilt, the opinion of the majority is that the entire pledge should be given and it is therefore printed on the official examination booklet as given under the regulations quoted before. This booklet is used in the examinations at the ends of the terms; it is the

opinion of some that it should also be used in written quizzes or review examinations, given once or more a month during the hour of class meeting, but this has not yet become a prescribed custom.

In conducting examinations, originally a committee of three was present during the period of the examination; this seems to be still the custom at the University of Virginia and is possibly a heritage from the method of holding examinations before the introduction of the honor system. It was soon abandoned at Vanderbilt and only the instructor giving the examination is present; even this one sometimes leaves the room for one or two hours during the examination period of three hours, but this is bad practice. The instructor should be present during the entire period, not primarily to watch the students, for the very appearance of watching to detect cheating is avoided, but to maintain order and silence and to give information that may be asked for regarding the examination questions.

For the successful operation of the honor system, the cooperation of the student body is essential; the honesty of examinations may be gauged by the jealousy with which the students guard their own self respect in the matter as evidenced by the report and trial of suspicious cases. The odium attached to talebearing can and will be overcome by the perception that dishonesty in examinations under the honor system is a reflection on the honor of the entire student body.

Among a large number of students, there will always be found some who will not only cheat if they think

they can do so without detection, but who will also sign the pledge after doing so. The method of procedure in the case of detection of dishonesty or apparent dishonesty on the part of a student by a fellow student has changed in the course of time at Vanderbilt. Originally the case was reported to the president of the class to which the suspected student belonged and he was tried by his own class. The occasion for the change from this system as well as the high regard in which the Honor System is held by the better class of students is indicated in the following article and editorial taken from the issue for February 8, 1900, of *The Hustler,* the weekly paper edited and published by the students of Vanderbilt University:

HONOR COMMITTEE ELECTED.

"It is generally known to the student body that some deplorable breaches of honor have been committed in the examinations of last term. These cases, though few, tainted the high standard of morals of the university and shocked the pride and feeling of the general student body immeasurably. It was necessary that the moral atmosphere of Vanderbilt be entirely and immediately clarified from these stains. We are 'on the honor system,' trusted as men of honor by our faculty and it is the duty of each and every member of the student body to show his appreciation of this trust not alone by his own conduct, but by insisting on the absolute honesty of others in his class. It is a point of honor among the several classes to keep their members up to the standard of the university and to be ready to punish any one who may break this trust immediately and without discrimination.

"In accordance with this feeling, the senior class met on Thursday afternoon, February 1, and the following motion was unanimously passed:

" 'Resolved, That a committee be appointed by the president of the senior class, immediately after his election, consisting of three seniors, to act in conjunction with the presidents of all four classes as a grand jury to investigate all cases of dishonesty on examinations and to submit them with proofs to the class to which the culprit belongs for action. This committee shall be known as the Honor Committee of Vanderbilt University and the president of the senior class shall be its chairman.'

" 'It was resolved further that this report be printed in *The Hustler*.' "

"The Honor Committee will be self-perpetuating. At the beginning of each year the president of the senior class will receive from the chancellor of the university the insignia of office, which will be presented before the student body. The sessions of the committee will be entirely secret and only its findings made public. Every student is expected to report cases of dishonesty to the president of his class, who reports to the Honor Committee. After investigation, the committee reports back to the class the result of its investigations and leaves the matter in the hands of the class. By this means all false reports are forever silenced and all true ones are verified and acted upon."

The Honor System.

"The necessity of an Honor Committee in the University is greatly to be regretted. We could wish that

the time had never come in the history of Vanderbilt when it was necessary to organize against dishonesty. But be it said to the honor and manhood of the students that when the time has come, and the use of unfair means in examinations has made it necessary, the students have faced the condition and have taken every step to uphold the high standard of integrity of character that has so long been the pride of the university.

"Some weeks before the intermediate examinations *The Hustler* called attention to the high standard of honor that the students had in the past insisted upon and declared that the students would not tolerate any one in the university who would not live up to that standard. Again, immediately before the examinations, Chancellor Kirkland, as he always does at this time of the year, strongly and earnestly appealed to the manhood of the students and begged them that rather than resort to unfairness, they would fail in every subject, that they would give up their diplomas rather than taint their characters. We had hoped that this would be enough, that those who had not been educated to the honor system would take warning. Indeed, it had been so long since a Vanderbilt student had betrayed his trust that we had almost come to hope that, so strong and unflinching was the sentiment against it, it would never happen again. But the student body is continually changing, and every few years some man, by failing to recognize the unwritten law, makes it absolutely necessary that the students write it for him in unmistakable, everlasting terms. This the student body at Vanderbilt has never failed

to do. The man who cheats on examination at Vanderbilt does a thing that no tie of friendship or love, however dear, will keep the students from openly recognizing and condemning. He places himself in direct opposition to the student body as a unit. Fellow students, class-mates, and fraternity mates, all, though with sadness, yet with firmness, say 'It is wrong; it must stop!' The verdict of the students, since the founding of the university, has been, and always will be, the same."

From the establishment of the Honor Committee in 1900, nothing objectionable in the student administration of the system arose until the intermediate examination at the close of the first term of the academic year 1905–1906. Charges of dishonesty during that examination on the part of two or three students were made to the president of the Honor Committee and he, instead of calling a meeting of the committee to investigate the charges, as it was his duty to do, took it upon himself to notify the accused parties of the suspicions against them and stating that if he heard anything more of the kind he would have to call a meeting of the committee to try them. This action on his part coming to the knowledge of some members of the faculty and the chancellor, the latter notified the chairman of the Honor Committee, that that disposition of the cases was unsatisfactory, that he had no discretion in the matter and that he must immediately call a meeting of the committee and proceed with the trial of the accused students.

It was to avoid, so far as possible, any such failure of the system as would have occurred had the action

of the president of the senior class mentioned above gone unchallenged that the constitution now governing the composition and duties of the Honor Committee was adopted. This constitution is given as Appendix I. of this paper. Under it, charges are made and the trial is conducted by students. If the suspect clears himself, or if the evidence is not sufficient to convince five of the seven members of the Honor Committee of his guilt, the charges are dismissed; if declared guilty, he must leave the university. Everything is done quietly and outsiders usually know nothing of these cases.

There are some cases of dishonesty which are not detected by students but which are discovered by members of the faculty. For example, in large classes students are sometimes compelled to sit so close together, that one may be able to read the paper of a neighbor without detection by a fellow student, but comparison of papers may show conclusively to the examiner that copying has been done. In such cases the practice is for the instructor to interview the suspected student, lay the evidence before him and call for an explanation. If the student pleads guilty, he is allowed to withdraw quietly from the university; if he continues to assert his innocence in the face of strong evidence of guilt, the case is laid before the faculty and if the evidence is sufficiently convincing, the student is ordered to withdraw from the university.

About half the members of the faculties of the academic and engineering departments have attended northern colleges as students, or as students and instructors, and they, as well as their colleagues, would

regard a change from the honor system as nothing short of a great calamity to Vanderbilt University.

Appendix I.

Constitution of The Honor Committee of Vanderbilt University.

Art. I. Name. The name of this committee shall be the Honor Committee of Vanderbilt University.

Art. II. Object. This committee is an organization of the students for their own protection. It seeks to preserve the integrity of the honor system at Vanderbilt. It aims to secure to any student under suspicion of dishonesty in examinations his full due and to vindicate his name, if innocent; to protect the honor and standing of the remainder of the students by his expulsion, if guilty. It purposes to do this in accordance with the procedure, rules and organization hereinafter set forth.

Art. III. Personnel. This committee shall consist of seven men as follows; One representative from the freshman class, academic and engineering; one representative from the sophomore class, academic and engineeering; one representative from the junior class, academic and engineering; three representatives from the senior class, academic and engineering; one representative from the junior and senior classes jointly of the pharmacy department.

It shall be the duty of the president of each class to call a meeting of his class, for the purpose of holding their elections, before November 1 of each year, and the members so elected shall serve for one year, or until their successors are elected.

Art. IV. Officers and their Duties. Sec. 1. The officers of this committee shall be a chairman, a secretary and a clerk.

Sec. 2. It shall be the duty of the chairman to preside at all meetings of the committee; to make all persons coming before the committee, whether witnesses to testify or accused persons to be tried, to take oath that they will tell the truth, the whole truth and nothing but the truth; to call a meeting of the committee immediately upon receiving from any student a written accusation against any student for using unfair means either to obtain or give help on any examination; and to perform all the duties common to his office.

Sec. 3. The secretary shall keep full minutes of all meetings and proceedings of all trials.

Sec. 4. The clerk shall summon the accused and the witnesses to all trials.

Sec. 5. Duties of Members. It shall be the duty of each member to attend all meetings, to investigate all rumors and suspicions which are heard, and to report results of investigations to the chairman.

Art. V. Incompetency of Members. No man shall be competent to sit on any trial if he is of any relation by blood or marriage to, or a member of the same fraternity as, the accused. The committee may, by a majority vote, declare a member incompetent on other grounds.

Art. VI. Filling Vacancies. Sec. 1. In case of a vacancy by a member withdrawing from college, the class shall elect his successor.

Sec. 2. In case of temporary absence or of in-

competency of any member of the committee, the remainder of the committee shall elect a member from the class of the absent or incompetent member to serve in place of said member during the time of his absence or incompetency.

Art. VII. Meetings. Sec. 1. There shall be one annual meeting of this committee for organization and election of officers. This meeting shall be on the first Monday in November of each year.

Sec. 2. Special meetings may be called by the chairman at any time.

Sec. 3. A special meeting must be called immediately upon receipt of a written charge signed by any student of the university.

Sec. 4. Seven members shall constitute a quorum.

Art. VIII. Form of Verdict. In case of trial, the verdict shall be "guilty" or "not guilty," and five votes shall be necessary to convict the accused.

Art. IX. Amendments. Amendments to this constitution shall require for their adoption five votes of the committee and ratification of the student body by a majority of votes.

Art. X. Disposition of Records. At the end of each scholastic year, the constitution and records of this committee shall be delivered by the secretary to the chancellor, to be presented by him to the new committee when selected the following year.

Appendix II.*

Henry St. George Tucker offered to his colleagues in June, 1842, the following resolution:

* Extracts from paper on "The Honor System at the University of Virginia in Origin and Use," by Professor W. M. Thornton, University of Virginia.

"Resolved, That in all future written examinations for distinction or other honors of the university, each candidate shall attach to the written answer presented by him on such examination a certificate in the following words: 'I, A. B., do hereby certify on honor that I have derived no assistance during the time of this examination from any source whatever, whether oral or written or in print, in giving the above answers.'"

That such a regulation was proposed and adopted would be proof, if proof were needed, that fraudulent devices had crept into the examination rooms. The original law of the faculty reproduced the practice common in the colleges of that day—the practice of the present day at Oxford and Cambridge and many other schools. Every examination was conducted by a committee of three professors under the following rule:

"A majority of the committee shall always be present during the examination, and they shall see that the students keep perfect silence, do not leave their seats, and have no communication with one another or with other persons."

The examinations are conducted to-day under Professor Tucker's resolution of 1842, extended to preclude by explicit pledge the giving as well as the receiving of assistance. The committee of three professors is still present, but simply to insure order and quiet, and to answer reasonable inquiries as to the question paper. The very appearance of watching the conduct of individual students is avoided. It is felt that the jealous self-respect of the student

body furnishes the best guarantee of honesty. Some of us habitually speak in a simple but earnest way to the first year classes at one of the closing lectures of the fall term on the attitude of the university towards its students in general, and particularly as to the examinations, and strive to impress upon them by affectionate admonition the genuineness of our trust in them and the reciprocal duty resting on them of a fastidious rectitude of action. But these admonitions seem even to us almost needless. So powerful is student tradition in these matters, that no student brings with him to the examination room anything but a fresh pad of paper and a fountain pen; that no two students willingly occupy places at the same desk; that no student leaves the room alone even for a few minutes; that no student ever visits his room alone during the examination hours for any purpose whatsoever. Not only with the faculty, but with the students themselves the prevalent belief is that the examinations are absolutely honest. The fact that at rare intervals some pitiful creature—usually a man strange to the traditions and ideals of the place—yields to temptation, cheats, and is detected, adds to our confidence in the prevalent rectitude. Where every man strives to avoid the very appearance of evil, the actions of such a student soon bring him under suspicion. His classmates, jealous of the fair fame of their class and of the university, observe him more carefully. We believe that such men are almost invariably first suspected, then detected, then expelled.

The procedure in such cases is the same in all departments. Each of these is organized into a class,

and elects a class president and other officers, who are charged with the duty of advancing the general interests of that class. The suspected student is at once reported confidentially to the president of the class. The charge and the evidence are laid by him before the class officers. If the evidence appears convincing, the student is called privately before these officers and confronted with his accusers. He hears the charge, the evidence is recited before him, and he makes his explanation. If he clears himself, the charge is at once dismissed, and nothing is ever heard of it by any outsider. If he cannot exculpate himself, he is given his choice of private withdrawal from the university, or a public trial. Usually the first of these alternatives is elected. If the student takes the second, he may have his trial either before his class or before the entire university, and the jury may be, at his option, composed of his classmates or may be an outside board of impartial referees. The faculty takes no part in the proceedings. In theory, even the convicted student has the right of appeal first to the faculty and the president, then to the board. In practice there is no appeal.

To think of the honor system as a mere artifice for securing honesty in the examination room, as an automatic machine for replacing so many keen-eyed proctors, is to miss the heart of the whole thing. The college officer who attempts to use it for ends so low, for purposes so mean, must not be surprised if it breaks down in his hands. To be effectual, it must be conceived as a vital principle, exalting to nobler ends and purer aims all the incarnations of the aca-

demic life. It ought to affect and it will effect, the outlook of the student mind upon all questions of conduct and duty. He is brought under its constraining force at an age when the sanctions of religious rearing often begin to lose their power; when the fresh new world of freedom and joy allures him with manifold temptations; when the nascent powers of virility produce in body and brain and heart the riotous springtide of youth and hope. Shall we account it a small thing if at this fateful moment we possess a discipline which helps to keep him straight and clean; which tells him in accents he can but heed that to be brave and loyal and true are man's peculiar virtues; which bids him embrace failure rather than stoop to fraud; which teaches him to despise an undeserved success and condemn an unmerited reward?

Discussion.

Professor Benjamin: There is one paragraph which says: "Only the instructor giving the examination was present, but that even this person sometimes left the room for one or two hours during the examination, a period of three hours, which was bad practice. The instructor should be present during the entire period, not primarily to watch the students, for the very appearance of watching to detect cheating is avoided, but to maintain order and silence and to give information that may be asked for regarding the examination questions." I would say this is why we have instructors present at examinations.

Dean Kent: One of my students once asked me about the honor system. I said, "What do you mean

by the honor system?" He said, "Where a man is put on his honor, and if he chooses to cheat, he will be the one to look out, you need not worry." I do not see how in the Northern colleges the honor system can be introduced, when the students come with the idea that cheating is not a very bad thing.

Professor C. R. Jones: In twelve years in West Virginia I have never been sure but of one case of cheating. Perhaps this was partly due to the fact that I tried to conduct my examinations so students could use all the books they wished. I am never afraid of them using any papers or any book that I don't wish them to see. I seldom use books in examinations, because the students often take too much time in looking up formulæ. I think that the real reason is that the engineering students are interested in their work. The year before last the junior law students resolved themselves into a society and wanted to put the whole university under the honor system. The law school had been accused of cheating, and the engineering students took offense at the law students trying to force the honor system on them. They would not draw up any resolutions along that line because it would put them in the light of having cheated in the past. I do not believe there is any cheating in our engineering school.

Professor Wood: I asked a class, at the spring examination, if they wished to have the honor system. I said to them, "It means two things, that you will neither give nor receive aid, and that you will report as a class any violation of that contract." They said they did not want it. The excuse was that it

had been tried and failed. But when Professor John Price Jackson induced the junior and senior classes in Electrical Engineering to take hold of the question seriously, the honor system had a fair trial and succeeded. There was a violation—a senior student who stood well in his class. The student committee took it in charge, found him guilty and they advertised his name on the bulletin board with the offense named, and stated reasons why the full penalty of expulsion should not be exercised in his case. The successful result has been because of their agreeing to report the man who violated the contract, or to take full charge of his trial and sentence. It may not work every place in the same way, but it has much to commend it when it becomes a student sentiment, and on the other hand is worse than no system if not upheld by the students to the letter. Where there is no occasion to raise the question of an honor system in a college, it would seem entirely uncalled for to keep the question rankling in the minds of the students.

Professor D. C. Jackson [Secretary in the chair]: I have known of instances of good men that ought to have been in the Tau Beta Pi Chapter, who were not there because they had not been perfectly fair in their examinations.

President Howe: The average college student is a pretty shrewd human being. When I hear a professor say there is no cheating in his class, I think he does not know the boys, for the boys can cheat under the nose of any professor that ever lived, if they want to. The majority do not want to

cheat. They wish to do honest work. They are honorable fellows, and come to college to do honorable work. But in every large class there are two or three men who will cheat if they get a chance, when they are in difficulty. As to the students telling of those who cheat, I must confess I have not reached the point where I believe a student would do it in all cases. I can imagine a case where the members of a football team, having played a good deal of football in the fall and done good work for the college, got behind with their studies. I doubt if there is a man in any college that would tell the class, or the institution, if a member of that football team had been cheating. Much depends on what we call cheating. If it is a case of a man looking over another man's paper—and papers can be seen quite a distance,—the student cannot detect the fact that one student has seen something on another man's paper and has used it. The only man that can detect it is the one that reads the examination papers and finds the similarity between the problems. I believe most of our cheating is of that character.

Professor Williston: It is not the student's business to maintain discipline in the institution, when the instructors and faculty and officers are hired and paid for doing it.

Professor Magruder: I cannot agree to that. One might as well say that it is not the business of every citizen of the United States to maintain order, as there is a police force hired and paid for that purpose. If I see fit to do wrong, no one would apprehend me till the police should happen to come and

catch me and of course no one would telephone for the police! Such a position in my opinion is poor ethics and poor civics.

DEAN KENT: Professor Williston took my side so very enthusiastically a while ago, I am sorry I have to be opposed to him now. It is enough for professors to have to attend to the training of the intellects of our students, without making policemen of themselves. And the same way about cheating. I would like to see the professors relieved from all such duties.

PROFESSOR WILLISTON: If it is such a disagreeable job, why should we insist upon putting it on a hundred or more poor innocent freshmen?

PROFESSOR MAGRUDER: We do not. We simply apply the principles of student government to examination room practice. The honor system in examinations originated at the University of Virginia and is in common and universal use, so far as I know throughout the south. I am thankful to learn that an increasing number of northern institutions have accepted it as tending to train students in honor, uprightness, and integrity, and that students appreciate the fact that when a fellow student cheats in classroom or examination, he not only cheats himself but robs them.

A CALCULATION BLUNDER COMMON TO MANY TEXTBOOKS ON TRIGONOMETRY USED IN ENGINEERING COLLEGES.

BY R. D. BOHANNAN,
Professor of Mathematics, Ohio State University.

The question at issue is this: If the field measurements on lines suggests primarily the use of the sine to determine an angle, and an angle near 90° is indicated, can the uncertainty of decision which the tables make in the case of the sine near 90° be reduced to a certainty, as the textbooks suggest, by the use of the tangent, or other function, of the half-angle? I shall attempt to show that this cannot be done in the case of actual field triangles, unless the field measurements indicate a degree of accuracy represented by measuring a line a mile long to within about five ten-thousandths of an inch, to calculate the angle to the nearest second.

To illustrate, I copy the following from a trigonometry textbook:

In the right-angled triangle, ABC, right-angled at C, let $a = 5235$ and $c = 5237.1$.

Then

$$\sin A = \frac{a}{c} = \frac{5235}{5237.1},$$

and A is near 90°.

$$\log \cdot \sin A = 9.99983$$

and A is $88° 21' 30''$ or $88° 25' 10''$, or some intermediate value.

Then the text goes on to say: In such cases the following more accurate method should be employed:

$$\tan\frac{A}{2}=\sqrt{\frac{1-\cos A}{1+\cos A}}=\sqrt{\frac{1-\frac{b}{c}}{1+\frac{b}{c}}}=\sqrt{\frac{c-b}{c+b}}$$

where b must be found from the relation

$$b^2=c^2-a^2=(c+a)\,(c-a)$$

where

$$c+a=10472.1$$

$$c-a=2.1$$

$\therefore$ (by logs)

$$b=148.3$$

Then

$$c-b=5088.8$$

$$c+b=5385.4$$

$$\therefore\quad \tan A/2=9.98770$$

$$A/2=44°11'19''$$

$$A=88°21'38''$$

[Here the quotation ends]

This process applied to the kind of measurement indicated in this example is entirely worthless.

$a=5235$ is subject to the error 0.5

$c=5237.1$ is subject to the error 0.05

Thus $c+a$ and $c-a$ are subject to the errors 0.55 and 0.45, the one to one error and the other to the other, without knowing which to which.

Thus in determining b^2 from

$$b^2 = (c + a)\ (c - a)$$

$$= 10472.1 \text{ times } 2.1$$

the error, possibly 0.55, in the relatively small quantity, 2.1, is multiplied by the large quantity, 10472.1. This subjects b^2 to an error of about 5770, or about 26%. And thus b (148.3 as given in the text) is liable to an error of about 13%. Therefore b is very uncertain, being between 127.4 and 166.6.

Thus $(c - b)/(c + b)$ lies between 5070.5/5403.7 and 5109.7/5364.5, from which it appears that log · tan $A/2$ lies between 9.98618 and 9.98945, or $A/2$ between 44° 5′ 19″ and 44° 18′ 14″ and A between 88° 10′ 38″ and 88° 36′ 28″. Whereas, by the first sine calculation, A was between 88° 21′ 30″ and 88° 25′ 10″.

By the refined process, A seems more uncertain than ever. However, in the sine calculation, the measurements of a and c were regarded as free from error. If rejection error had been allowed for, the uncertainty from the sine would have widened, of course, and to an extent easily calculated.

What a textbook example like this means, as to measurements in the field, appears when we notice that the sides $a = 5235$ and $c = 5237.1$, if taken as in feet, represent lines nearly a mile long, while in c the tenth of a foot was taken into account. For some reason a was not measured so carefully. Now measuring a mile to the tenth of a foot, a little over an inch, is close measurement—better than is done in city surveying on expensive frontage.

Observe the effect of omitting this 0.1 in c; b^2 is changed by about 1047, or about 5%. Thus b is

changed by about $2\frac{1}{2}\%$, or by about 3.7, or, say, 4. Then b lies between 144 and 152, and this makes A doubtful between $88° 20' 10''$ and $88° 27' 24''$, which is still a wider range than the sine gave, $88° 21' 30''$ and $88° 25' 10''$.

The proper attitude toward all cases like this, where the field-measurements lead, primarily, to a function for which the tables reply uncertainly as to the angle, is to go again to the field and make other measurements. Any attempt to overcome the effect of injudicious field-work by high-art paper-work, involves generally, as here, multiplying a small quantity, subject to possible error, by a similar relatively large quantity. Thus the error in the small quantity is multiplied by the large quantity, vitiating the calculated quantities.

The proper direction to the engineering student is to *avoid* field-measurements leading to the determination of an angle from the sine, when the angle is near 90°.

The same textbook from which I have quoted goes on to say:

The same difficulty is encountered in oblique triangles when the law of sines is applied to calculate angles near 90°.

Let

$$b = 2, \quad a = 1.06, \quad A = 37°$$

Then

$$\sin B = b \sin A/a$$

and

$$\log \cdot \sin B = 9.99993$$

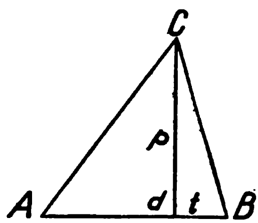
and B lies between $88° 56' 10''$ and $89° 0' 30''$.

To determine B more accurately, drop the perpendicular CD on AB. Let $CD = p$ and $DB = t$.

$$\therefore \quad p = b \cdot \sin A = 1.05983$$

and

$$t^2 = a^2 - p^2 = (a - p)\,(a + p)$$
$$= 0.00017 \times 2.11983$$



Here again is a small quantity, subject to rejection error, multiplied by a relatively large quantity, and the case is as before.

Of course, however, if the figures given for b, a, C (2, 1.06, 37°) represent actual measurements, the whole procedure is only an amusing refinement in calculation. The length, $b = 2$, is subject to the rejection error, 0.5, which renders the five decimals in p meaningless. But even when the lengths represent sane (even though very sensitive) measurements, the difficulty remains ineradicable.

The following example, taken from another textbook, will illustrate this.

Let $c = 1.08261$ and $b = 1.08249$, to solve the right-angled triangle. B is near 90° and the tables give an uncertain answer from sine B.

We may use

$$\sin\frac{B}{2} = \sqrt{\frac{c - a}{2c}}.$$

where

$$a^2 = c^2 - b^2 = (c - b)\ (c + b)$$
$$= (0.00013)\ (2.1651)$$
$$= 0.00,02,59,81$$
$$\therefore \quad a = 0.016119$$

and

$$B/2 = 44^\circ\ 34'\ 24''.3$$
$$B = 89^\circ\ 8'\ 48''.6$$

Here the field measurements represent considerable refinement.

The fifth decimal place is cared for. If the figure, 1, preceding the decimal in b, c represents a foot or an inch, the accuracy indicated is on the borderland of all possible accuracy. Even if a mile is in mind, an accuracy of measurement of about 0.4 of an inch in a mile is indicated.

The indicated error in both b and c is the small quantity 0.000005.

Thus either $c - b$ or $c + b$ is liable to the error 0.00001.

Thus $a^2 = 0.00,02,59,81$ is liable to the error 0.00,00,21,65.

Thus a^2 is uncertain in the third doublet of decimals, and a^2 lies between 0.00,02,81,46 and 0.00,02,38,16.

Thus instead of a being exactly 0.016119, as the book gives it, it is certain only as far as 0.01; that is, to only one significant figure.

Thus is the determination of B by this process worthless.

To insure B correct to the nearest second we should

know a to five significant figures. To calculate a to this closeness requires that b, c be measured far more closely.

If a has the error x, a^2 has the error $2ax$, nearly. If a here has an error of 1 in the last significant figure, the error in a^2 is 2 times 0.016119 times 0.000001. But by the process, the error in a^2 is at most $c + b$ times the error in $c - b$, or $b + c$ times twice the error in b or c.

$$\therefore \text{ allowable error in } b \text{ or } c = 0.016119 \times 0.000001 \div 2.1651$$

or less than half the numerator.

The allowable error in b and c is then less than eight billionths of a mile in a mile measurement, which is about five ten-thousandths of an inch in measuring a mile!

A NEGLECTED OPPORTUNITY TO TEACH CONSISTENT MEASUREMENT IN TEACHING TRIGONOMETRY.

BY R. D. BOHANNAN,

Professor of Mathematics, Ohio State University.

When an engineer says a line is 27 units long, he rarely wishes to be understood as meaning exactly 27. If he is reading to the nearest unit, he calls any reading 27 which lies between 26.5 and 27.5, the lower limit included, the upper limit excluded.

When a textbook on trigonometry gives the side of a triangle as 27, it means, very generally, 27 exactly, just 27 and nothing else, and the calculation of ungiven parts is carried to a closeness having no bearing on the data and limited only by the tables at hand.

With an engineer 27, 27.0, 27.00, have very different meanings, when they indicate measurements. In the first the figure in tenths place is not known and the 7 may have come from 6.5. In the second, the figure in hundredths place is not known, and so on.

In a textbook on trigonometry, 27 and 27.0000000,—zeros "world without end,"—mean one and the same thing.

These two points of view are very different. The one has to do with a real world, the other with triangles that never were, either on land or sea.

The student trained in the textbook point of view, will go into a physical or mechanical laboratory, or

an engineer's office, and promptly makes a fool of himself.

It is about time the textbooks used in engineering schools paid heed to engineering usage.

However, it remains always quite essential that the "scientifically" trained student pay heed always to common sense and his environment. If he becomes a carpenter's assistant and is directed to saw a plank 8 feet long and brings in one somewhere between 7.5 and 8.5, he will promptly lose his job.

The number of significant figures in a reading gives an indication of the care that was intended when the measurement was made. For the reading 27, the largest error intentionally made by the reader was 0.5, as when 26.5 was called 27. The "relative error" is thus $0.5/27 = 1/54$. The relative error in the reading 27.0 is $0.05/27.0 = 1/540$. The relative error in any reading is thus unity divided by twice the reading without regard to decimal point.

Two readings showing the same number of significant figures, will show, in most cases, about the same relative care in measurement. The readings 36.27 and 4143 show the relative errors 1 to 7254 and 1 to 8286, which are reasonably near together. The widest discrepancy occurs, of course, between the smallest and largest sequence of the given number of places, as for example, in 1000 and 9999, in four place readings.

It is evident that in the simple diagrams of ordinary trigonometry, all the measured lines should show about the same relative care in measurement. If one side of a rectangle is about 816 feet and the other about 7 feet, the short side ought to be measured

to at least 2 decimal places. A neglected 4 in tenths place will alter the area by about 326 square feet. It is thus apparent that the measured lengths of sides in a triangle, given as an illustrative example in trigonometry, should show, as a rule, the same number of significant figures.

Very few textbooks pay any heed to a matter so self evident as this.

Examples like $b = 263$, $a = 148.228$, $A = 34° 17'$ (copied from a recent text) can doubtless be selected from the first trigonometry you pick up. Such an example indicates that for some reason not plain at all, a was measured to within one 296-thousandth of its value and b to only one 526th of its value.

Another matter to which the textbooks pay little or no attention, is having the angle-readings show care commensurate with that of side-readings.

It is evident that if the sides of a triangle show only four significant figures, or less than four, the angles ought not to read to the nearest second, for the angles can generally be changed by a second without effecting the fourth figure in the tables, and thus without effecting the fourth figure in sides. And, similarly, when the sides show three significant figures, or less, the angles should not read to the nearest minute, since angles in the table can be changed for a large part of the tables by a minute without effecting the third figure in the tables.

$$\log \tan 13° 10' = 9.369$$

$$\log \tan 13° 11' = 9.369$$

and the like.

What the books disregard is that if a measurement represented by a single significant figure is divided by another of the same kind, the quotient can, as a rule, be taken to only one significant figure, without being effected by rejection error. The books tacitly carry the division as true to as many places as the tables used, no matter how many figures the measurements showed.

If a four-figured measurement is multiplied by another four-figured measurement, about half of the figures of the product are doubtful and thus meaningless. For example,

$$\begin{array}{ll} \text{Multiply} & 26.3\mathit{4} \\ \text{by} & 31.2\mathit{9} \end{array}$$

Let the italicized figures indicate that they are doubtful. Then the doubtful *9* multiplied by the first upper number, in the ordinary way, renders the first line of the product, all doubtful. Then 2 times doubtful *4* makes the first figure of the second line in forming the product, doubtful. And so on. This forms the basis of a fundamental rule in calculation almost uniformly disregarded by texts on trigonometry:—The calculated sides and the calculated functions of angles should not show more significant figures than the measured lines.

In determining an angle from one figure in the sine, the average error for the whole table is about 3° 30′. And from two figures about 20′. We may call the one 5°, and the other 30′.

The following rules show, fairly well, consistent measurement and sane calculation:

1. Let all measured lines and all calculated lines show the same number of significant figures, as a rule.

2. When the lines show only one significant figure, let angles read to the nearest 5°.

3. When lines show two significant figures, let angles read to the nearest half degree, as with the surveyor's compass.

4. When lines show three significant figures, let angles read to the nearest 5′.

5. When lines show four significant figures, let angles read to the nearest minute when a four-place table is used and to the nearest 10 seconds when a five-place table is used.

6. When lines read to five significant figures, let angles read to the nearest 10″ if a five-place table is used and to the nearest second if a six-place table is used.

7. In astronomical work, when the number of added logarithms is sufficient to assure balancing of rejection errors in the logarithms themselves, five figures in lines call for seconds in angles: six figures in lines, tenths of seconds in angles; seven figures in lines, hundredths of seconds in angles.

8. If five-place logarithms are used on five-figured data in ordinary trigonometrical calculations, where often only three logarithms are combined, the rejection error in the logarithms being too few to balance will make the last figure of the combined logarithms uncertain by 1.5, that is by 2, that is by 2.4, so far as tables go, which prevents getting a calculated angle to the nearest second when a five-place table is used

on five-place data. Similarly with a four-place table on four-place data.

9. A table going one place beyond the place of the data is always sufficient, and lessens the effect of rejection error in the tables on calculated results. Cut back a larger table to one place more than the data.

A point in which textbooks are often amusing is in exhibiting a very careful observer under rather trying circumstances, for example, this (quoted from a book):—

"A man in a balloon wishing to know his height above the earth, observed the angles of two objects on the earth and in the same vertical plane as the balloon, and 1200 feet apart, to be 33° 22′ and 22° 18′, respectively, how high was the balloon? Ans. 1304.7 feet."

How did the balloonist hold himself still long enough to measure these angles, and with what apparatus did he measure? He succeeded in locating himself to within 5 hundredths of an inch, which was doubtless very comforting. If there had been a pebble immediately under the balloon, he would have been justified in asking that it be removed, since he wished to know his distance from the bottom of the pebble and not from the top.

No class of profane literature that I know of has succeeded in divorcing itself from all that is mundane and all that is reasonable so completely as have illustrative examples in the textbooks on trigonometry.

ATHLETICS FOR ENGINEERING STUDENTS.

BY CHARLES L. THORNBURG,
Professor of Mathematics and Astronomy, Lehigh University.

I assume that it will be conceded by everyone here present that "A sound mind in a sound body" is a wise saying and especially applicable to the class of men called engineers. Some, if not the majority, of the faculties of our educational institutions seem to lay great stress on, and devote much time and effort to, the "sound mind" part of the saying and little or no attention to the "sound body" part of it, leaving that to nature and chance. The writer believes that both are equally important and that if greater emphasis is thrown on either part it should be on that of the body, for without a sound body the mind cannot do its best work.

It is difficult to account for the attitude of many educational institutions on the subject of athletics; too many of them leave the management and control of athletics to their students, without the proper regulation and control that they should have in order to secure the best results, hence have grown up the abuses that we decry. The recent organization of the Intercollegiate Athletic Association of the United States, composed of members of the faculties of some sixty or more colleges and universities, is a step in the right direction and should result very soon in great good both to the cause of education and athletics. This movement grew out of the abuses that were rampant

in the football sport, and the first work of the association was to improve and regulate that, but at the last meeting, held in December, 1906, resolutions were adopted looking toward the proper regulation of baseball and basket ball, and a resolution was also adopted requesting the faculties of the various institutions belonging to the association to take steps to regulate the number of intercollegiate contests for each branch of sport. This has already been done in certain sections of the country, but it should be done in all of them; fewer intercollegiate contests should be held and greater stress should be thrown on inter-class, inter-fraternity, and inter-club contests, and the benefit of outdoor athletics brought to the greatest possible number of the students of every institution of learning.

Athletics at each seat of learning should be under the general oversight of a trained director of physical education, who should be of the grade of professor with a seat in the faculty, and who should be responsible for his department to the same extent and degree as the professor of civil or mechanical engineering is responsible.

Gymnasium work should be required of every student for at least one year with not less than two hours work per week; if for any reason of physical disability the student's family physician prohibits this, he should be required to take an equivalent amount of work of some kind in its place. This is so at Lehigh University and no student can graduate until he has satisfied this requirement. I would go further than this and require that certain students,

with weak and undeveloped bodies and consequent poor health, should, when the judgment of the professor of physical education says it is necessary, be required to take regular exercise under his direction throughout their whole college course or as much of it as is decided upon by the professor. The gymnasium work should not consist wholly of physical exercise, but the students should be instructed in the proper care of the health and the body, and their protection from abuses and diseases; the exercises should be regulated to correct the defects and weaknesses of the individual student, as our best physical educators know so well how to do. A large part of the gymnasium exercise should be done out of doors.

After the period of gymnasium work has been completed as many students as posible should be encouraged to take part in the different branches of athletic sports, and to secure this end each educational institution should provide and equip as many athletic fields as necessary so that the benefits of this kind of training shall be made possible to all students, and not confine it, as at present, almost wholly to the candidates for the so called "varsity teams."

What has been said thus far is applicable to any kind of a student, and in fact I fail to see the difference between an Engineering student and any other as far as his relation to athletics is concerned. I have been intimately and very actively connected with the management of athletics for the past fifteen years, and as secretary of the faculty for the past eight years, I know the scholastic standing of the student body. At Lehigh University our best and

our poorest students engage in athletics, and I give it as my judgment based on years of experience that athletics, per se, are not detrimental to scholarship, and that if properly managed and controlled they would be an aid rather than a hindrance. Almost invariably the scholastic standing of weak students, who are athletes, has been found better in the term in which they were playing football or baseball than in the one in which they were not playing. It may be thought that one reason for this result is a rule which some colleges have requiring a certain grade of scholarship of the students engaged in athletics, which is not required of other students, nor of athletes except when members of a team. This is not so at Lehigh University; any student whose scholarship permits him to remain in the university is to that extent qualified to engage in intercollegiate athletics.

Some years ago a weak student who was an athlete was placed on probation by the faculty, as to his scholarship, on motion of the head of his department; the question was raised as to whether he should be ordered to stop playing baseball, whereupon the department head replied "No it will do him good to play."

I am aware that many engineering educators will admit the benefit of athletics but will deplore the loss of time devoted to them, which in their opinion had better be spent on engineering work. I do not agree; I do not call the time lost; but some will say, we have no time for athletics, we need all the time for shop, drawing, field, and laboratory work; my reply to this argument is, do less shop, drawing, field

and laboratory work, or rearrange your roster, or cut down some of the other required work to such an extent that the students may devote some time to athletics and you will graduate better embryo engineers. At Lehigh University in the fall and spring months as little work as possible is scheduled after 4 p. m., and no work is scheduled on Wednesday and Saturday afternoons at any time.

We cannot make engineers, we can only give our students the underlying fundamental principles of the science of engineering and develop in them, as best we can, the power to think and reason correctly, accurately and rapidly; they must make engineers of themselves after we graduate them.

The President of the Bethlehem Steel Company recently said to me that in choosing men to do his work, of two graduates equally well prepared scholastically, he would give preference to the one who had been an athlete, because as a general rule that man would get out the work he was assigned to do quicker and better than the other man, because his athletic training had taught him to act quickly and accurately in the face of opposition and difficulty.

In my judgment the faculties of the universities and colleges of the United States should take a firm hold on the management of their athletics, and see that they are conducted on a strictly amateur basis, under well regulated business principles, fairly and honorably in all particulars, and aid in improving their moral tone and in making them more useful.

WHAT SHOULD BE INCLUDED IN A COURSE IN ENGINEERING JURISPRUDENCE?

BY A. H. BLANCHARD,
Associate Professor of Civil Engineering, Brown University.

The engineer of the future will be expected to be familiar with all the principles of law which may be encountered during the conception, construction and development of engineering projects. The fact as above stated has been recognized during the past five years by practically all the first-class engineering schools in the country. The necessity for the introduction of a course in engineering jurisprudence being now admitted, the scope of the course should be carefully considered. The character of the law courses given in various institutions varies from a brief course in contracts and specifications, or a course in so-called business law, to a course in engineering jurisprudence.

A comprehensive course in engineering jurisprudence should include contract law, legal documents, general law governing the relationship of capital and labor, elements of patent law, partnership, negotiable instruments, real property, water rights, ownership, rights of way, franchises, boundaries, incorporeal rights, expert testimony and the legal status of town, city, state and federal governments.

In order to treat the program outlined above satisfactorily it will be necessary to devote thirty hours

to the course, twenty hours being assigned to the law of contracts and ten to the remaining subjects.

In that part of the course devoted to the law of contracts, besides treating exhaustively the fundamental principles, special emphasis should be placed upon those subjects, the misunderstanding or ignorance of which is the cause for the majority of the cases of litigation. The following list includes the important subjects which come under the classifications referred to above: first, second and third parties to a contract; plaintiff and defendant; sureties and their liabilities; competency of principals, agents, corporations, co-partnerships, labor unions, boards, committees, councils and town, county, city, state and federal governments; relationship between principal and agent; liabilities of public agents; statutory limitations governing public agents; legality of the instrument, including the multiple phases of the duties of the engineer as arbitrator and the related subject "condition precedent"; illegal contracts; elements of an agreement, such as mutual understanding; distinction between an agreement which may become a contract and a contract; legal status of oral or written agreements not included in the contract and made prior to signing of same; subletting of contracts and limitations governing the same; status of written additions to printed form of contract; injunctions; ambiguity and interpretation of contracts; plans and specifications part of contracts; the offer and the acceptance; qualified agreements; frauds and remedies for the same; "valuable consideration" and its relationship to alterations in contracts; contracts

under seal and parole contracts; oral and written contracts; various methods of discharge of contracts, including the legal status of "an act of God or of the public enemy"; abandonment of a contract; breach of contract and remedies for the same, including a detailed consideration of the distinction between liquidated damages and penalties; legal limitations governing the discharge of the right of action under a contract.

The law of contracts may be treated by three different methods; first, exclusively by the case system; second, by the textbook method; and third, by a combination of the case and textbook methods. The case system has the disadvantage, especially in a short course, of presenting to the student a collection of more or less heterogeneous principles of law which are correlated with difficulty. The complexity of detail renders the second method unsuccessful, as it is difficult for the average student to appreciate the importance of a particular principle when treated in conjunction with many corollaries and exceptions of a similar character. Judging from experience with the three methods outlined, the combination of the case and textbook methods yields the best results. If either of the standard texts, Wait or Johnson, are used, the subject matter can be covered in twenty assignments, and in addition thereto three cases may be given in connection with each assignment, which number usually will be sufficient to cover the important principles. By using this method it is possible to emphasize all the important principles listed above by the illustrative cases assigned, and by the aid of

brief cases given in class bring out the exceptions and secondary situations which may arise.

The following cases are given as examples of those which may be used to illustrate cardinal points in contract law. The first case cited emphasizes the fact that a contract is completed upon the mailing of the acceptance, provided the mail was used by the offerer as an agent.

ADAMS (A) vs. LINDSELL (L).

L in Albany by letter offers to sell to A in New York certain specified goods provided he receives an answer by return mail. L's letter being misdirected, the answer notifying L of the acceptance of the offer arrived two days later than it would have done had L correctly directed his letter. On the Monday following the Friday on which A posted the acceptance and preceding the receipt of A's letter by L, L sold the goods to a third party; hence A sues L for damages.

The second case calls attention to the importance of a thorough knowledge of the relationship between principal and agent.

TOWN OF ESSEX *vs.* TERRY BRIDGE CO.

At 3:30 P. M., Thursday, March 9, 1899, the agent for the defendant signed two contracts, one to build complete a reinforced concrete arch bridge and the other to deliver, on completion of said bridge, five rock drills at the town farm adjacent to the site of said bridge. At 10 A. M., Thursday, March 9, 1899, M. W. Terry, president of the Terry Bridge Co., and an independent manufacturer of rock drills, died.

The defendant, continuing the business of building bridges, constructed the bridge, which was accepted, but as the aforesaid rock drills were not delivered, a suit for damages was filed by the plaintiff.

The third case illustrates the difference between an agreement and a contract.

POST *vs.* WEST SHORE R. R. CO.

Plaintiff in 1890 bought two tracts of land for manufacturing purposes. The tracks of the West Shore R. R. Co. were located on an embankment, twenty feet in height, which separated the two tracts of land. In December, 1891, the plaintiff made an agreement with the defendant to the effect that if the defendant would provide a tunnel crossing before May, 1892, the plaintiff would erect on one tract of land a manufacturing plant and on the other a model mill village. Plaintiff fulfilled his part of the agreement and seeks in this action, brought in June, 1892, the enforcement of the specific performance of the agreement on the part of the defendant.

The essentials of the various legal documents used by engineers, such as advertisements, proposals, contracts, bonds and specifications will, as a rule, be thoroughly comprehended if examples are discussed and criticised. The dearth of knowledge of the requisite factors of legal engineering documents is tritely illustrated by a glance at a page of construction advertisements in any of our leading technical papers. At present seventy-five per cent. of such advertisements are either ambiguous, incomplete, over-crowded or indefinite. The particular class of documents referred

to, namely, advertisements, may be adequately dealt with by first considering the importance and value of the essential elements of advertisements, such as, time and place of opening bids, right to reject any and all bids, required certified check, et cetera: secondly, by assigning typical erroneous examples, found in engineering journals, which must be discussed and criticised and finally revised. Proposals, contracts, bonds and specifications may be presented in a similar way, emphasizing and requiring an explanation of the bearing of all the legal clauses which have been previously considered in contract law.

At the present time it is necessary to treat such subjects as the general law governing the relationship of capital and labor, elements of patent law, partnership, negotiable instruments, real property, water rights, ownership, right of way, franchises, boundaries, incorporeal rights, expert testimony and the legal status of town, city, state and federal governments by the lecture method with the usual dependent recitation. Although some of these subjects are covered by miscellaneous pamphlets, the majority of the subjects are not included in any one treatise. Wait's two excellent works, the "Law of Operation Preliminary to Construction in Engineering and Architecture" and "Engineering and Architectural Jurisprudence" cover many of the subjects enumerated, but unfortunately both books are somewhat bulky for use in the class room. Granting that all the subjects mentioned are essential, it is to be hoped that in the near future a textbook may be written giving in one treatise of reasonable proportions the entire field of law which pertains to engineering.

REPORT OF COMMITTEE ON NECROLOGY.

JAMES ROWLAND WILLETT.

Born in Dublin, Ireland, June 23, 1831, but at an early age came to Philadelphia. He was graduated from the Polytechnic College of Pennsylvania on March 2, 1854, as a Bachelor of Mine Engineering. He was practising in Missouri in 1861. He at once raised and commanded a company of scouts in the Union service under General Lyon. Appointed Lieutenant of Engineers and attached to the Thirty-eighth Illinois Volunteer Infantry, he participated in the march to Pittsburg Landing and Corinth, returning to Nashville and taking part in the Battle of Stone River.

As Post Engineer at Nashville in 1863 and as Engineer of Fortifications in 1864 under General Rosecrans, he contributed largely to the final triumph of the Union in the west.

Promoted to Major in First U. S. Veteran Volunteer Regiment of Engineers in 1864, he was posted at Atlanta, but was present at the Battle of Nashville.

He was mustered out at the close of the war with the rank of Brevet Lieutenant Colonel, with the record of a brave officer and an efficient engineer.

Joining George H. Thomas Post No. 5 in 1879, he remained an honored comrade until his death on May 9, 1907.

After the war he became Superintendent of Construction of a Government Building at Nashville, where he soon commenced practice as an architect. The Chicago fire in 1871 transferred him to that city, where he designed many buildings of great importance, especially for public use.

His principal works are the Times Building, the French Flats, the first large apartment building in the city, and the residence of the Roman Catholic Archbishop of Chicago. His most important public building is the Kankakee Hospital for Insane, where he first introduced the cottage system for housing the less violent inmates.

He became a member of the American Institute of Architects in 1870, and of the Society for the Promotion of Engineering Education in 1896.

Collecting a valuable library of scientific books, he retired from his profession in 1900, devoting his well-earned leisure to the study of his favorite sciences, especially to the heating and ventilation of buildings and to graphic statics, on which he frequently published valuable original papers. He first made known the graphical method for determining the reactions at the ends of a loaded beam or truss now in common use; removed the difficulties in the solution of irregular Fink trusses; discovered some interesting relations between shear area and bending moment of a beam.

He died in Chicago, Illinois, May 9, 1907.

He leaves to us the memory of a successful engineer and architect, a pioneer in applied science, and of a fatherly counsellor to young men in his profession.

N. CLIFFORD RICKER,
ALFRED F. BASHLEY.

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